

ORAL HISTORY PROGRAMME, ENGINEERS AUSTRALIA

INTERVIEW WITH MR JOHN GILBERT MARSH

at Fremantle, Western Australia
on 22 & 29 January 2009

Interview by Richard Hartley

Tapes 1, 2, 3, 4 and 5

Tape 1, Side A

minutes

- HARTLEY 00 This is Richard Hartley interviewing Mr Gilbert Marsh at his house in Fremantle on Thursday the 22nd January 2009 for the Oral History Programme of Engineers Australia.
- Mr Marsh, or may I call you Gilbert?
- MARSH Yes.
- HARTLEY To start our interview, could you please tell us your full name, when you were born and where?
- MARSH My full name is John Gilbert Marsh. I am called Gilbert as my father was also called John or Jack, but I probably should have had Gilbert as my first name. I was born in Salisbury, England on 22nd November 1925.
- HARTLEY And who were your parents?
- MARSH My father was John William Marsh. He was a farmer and my mother was Isla á Becket Marsh or rather Isla á Beckett Chomley, her maiden name, and she was a journalist on my grandfather's journal called *The British Australian and New Zealander*.
- HARTLEY That was an expat journal, wasn't it? That was for expat Australians and New Zealanders.
- MARSH 02 Yes. My grandfather had been a barrister in Melbourne, but he disliked the law and my mother's grandmother financed him to set up this journal in London. And so the family left Melbourne and went to England. It was grandfather in 1905 and my mother and the rest of the family in 1908.
- HARTLEY That was Mr á Beckett, was it?
- MARSH No. Great grandmother was an á Beckett by marriage and my grandfather was a Chomley – I think he was born in Ireland, so the Chomleys came out from Ireland.
- HARTLEY It is spelt with an "O", is it? Chomley. Is Chomley spelt C-H-O-M-L-E-Y?

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- MARSH C-H-O-M-L-E-Y. Not Cholmondeley but C-H-O-M-L-E-Y
- HARTLEY Where does á Beckett come in then?
- MARSH 04 My grandmother's maiden name had been á Beckett. She was the daughter of Emma née Mills. Emma's father had been a convict. He'd been transported to Tasmania in 1826 and he was the first brewer in Melbourne, made a lot of money, died in 1841 and left all his money to his only child, Emma. And she married the Chief Justice's son. The Chief Justice was named William á Beckett and their son was also, I think, William á Beckett. So that's where it came from.
- I think they were descendants of or somehow connected with ..
- HARTLEY Thomas á Beckett, was it?
- MARSH Thomas á Beckett, yes, but I think they were probably connected, somewhere.
- HARTLEY So how is that spelt?
- MARSH á Beckett.
- HARTLEY It's an interesting marriage – a convict and a ...
- MARSH Yes well, money made the difference, I think, because she had lots.
- HARTLEY That was the first brewery in Melbourne, you said.
- MARSH First brewery, yes. First brewery in Melbourne, yes.
- HARTLEY Gosh, no wonder he made all that money.
- MARSH He got his ticket of leave in 1829 and came over to Melbourne in that year, I gather, and opened the first brewery.
- HARTLEY So he went to Tasmania, did he, or Van Dieman's Land?
- MARSH Yes, and learned brewing when he was a prisoner there.
- HARTLEY Very useful trade.
- MARSH 06 Yes, a useful trade, yes. It was a funny thing. I only learned in recent years about the family history. My mother never told us.
- HARTLEY No, that generation never did.
- MARSH Yes. Because one of the other daughters – Minnie á Beckett – she married the Boyd who fathered the Boyd dynasty.
- HARTLEY Oh really?
- MARSH Yes
- HARTLEY A very illustrious family.

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- MARSH Yes. Well my mother was quite a good artist. Minnie Boyd was a good artist. She married a guy named Arthur Boyd. He was the grandfather of the recent Arthur. But I read about them in the history of the Boyds. I read about all my forebears in the history of the Boyds. That's where I learnt it.
- HARTLEY So what happened after á Beckett died? What happened to his wife?
- MARSH 07 After William Á Beckett died?
- HARTLEY Yes
- MARSH Well, she was the matriarch of this extended family and so my mother grew up in this artistic community, if you like. I know as a kid, we were given tablets, drawing tablets, to draw [laughter], so I used to draw a bit as a kid but I didn't keep it up.
- HARTLEY No wonder you were such a good draughtsman though.
- MARSH My brother's quite a good artist but I didn't inherit any of those gifts.
- HARTLEY 08 So what happened to the children in England.
- MARSH My grandfather and my grandmother, they died during the war and then my aunt, she kept the journal going and it was still going in ... well, 1962. Then it was still going, but I am not sure what happened to it after that. Eventually, I think it just petered out.
- HARTLEY That was published in London, was it?
- MARSH Yes, in London.
- HARTLEY So how did you mother meet her husband?
- MARSH 09 She was a Land Army girl in the First World War and my father was a farmer up in Leicestershire (I think it was Leicestershire, or Shropshire) anyway it was somewhere near there, and he had a rheumatic heart so – all his brothers had gone to the war, but he carried on the farming. Anyway she was the Land Army girl and helped with the farming and then, after the war, she had a proposal from him to marry. She also had a proposal from somebody else, a Victorian guy, so her grandmother financed her on a trip around the world to make up her mind. [laughter]
- HARTLEY Oh!
- MARSH 10 I think she had been a bit keen on Penleigh Boyd and Penleigh married somebody else and so she was ... anyway, that's reading between the lines. And she came back and she accepted my father's proposal and married him in 1923.
- HARTLEY How did she persuade him to go to Australia, or was that his idea?
- MARSH Well I don't know. I think she was wanting to get back – because we had a very good farm. He farmed with his brother at Middlechase and that had 800 acres of wood so, you know, it was a pretty sort of prosperous farm. She wanted to get back to Australia, I know that. So we came out in 1928. Around towards Christmas 1928. I think I was about three, and I am not sure. We

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went broke during the Depression. We only had a small mortgage but the crop was frostbitten and we couldn't meet the repayments and so the Agricultural Bank, as it was called then, foreclosed.

HARTLEY Where was the farm?

MARSH Harrismith.

HARTLEY Harrismith. Is that midway between Narrogin and Kulin?

MARSH That's between Wickopin and Kulin.

HARTLEY Oh.

MARSH 12 Wagin, yes. Out that way anyway. It is on the same line as Kulin. And so I commenced schooling there when I was under age. It was a one-teacher school and they wanted some extra pupils to justify the school. So I could do what I liked, and so I remember doing decimals and fractions because I was so interested in maths. I found maths fascinating.

HARTLEY At aged five? [laughter]

MARSH My father was fortunate enough to get a job on the mines in Kalgoorlie and then he commenced building a house there and in the meantime we went up and stayed with my mother's Chomley relatives on Sturt Meadows Station and we were up there for, I am not sure how long – six months or more.

HARTLEY That's Sturt Meadows?

MARSH Sturt Meadows Station.

HARTLEY Is that the one near Leonora?

MARSH Yes. And when we came down, the house wasn't quite finished. We lived in tents for a while on the block, and eventually we moved in.

HARTLEY So when your father and mother went to the farm in Kulin, was it a virgin block?

MARSH No it was an established farm. Yes, we bought it from a guy named Mackenzie. I don't know what happened to it. I haven't been back to the place. My brother has, but I never went back.

HARTLEY Were you the eldest of the family?

MARSH 14 No my sister was the eldest. She's 14 months older.

HARTLEY What were their names, your siblings?

MARSH Rosemary, and my brother is Brian á Becket Marsh.

HARTLEY Oh.

MARSH Yes. He was in the Agriculture Department and my sister became a social worker and she moved over east and was a social worker in mental institutions for many years.

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- HARTLEY She was born in 1924?
- MARSH She was born in 1924, that's right.
- HARTLEY And your brother, when was he born?
- MARSH He was born in 1927.
- HARTLEY So you were all Poms really. [laughter]
- MARSH Yes, that's right.
- HARTLEY Do you remember much of the farm?
- MARSH Yes, I can remember the farm. It was on a creek. I used to go out, and I remember operating on frogs. [laughter] Big frogs in the creek.
- HARTLEY Not vivisection, I hope. [laughs]
- MARSH [laughs] Yes, I am afraid so!
- 16 I can always remember food. I can remember the huge mushrooms we used to get along the creek and we had a nanny who came out with us ... and the baking, you know, eating gingerbread men and that sort of thing. And the harvesting.
- HARTLEY Did they have a tractor in those days? Or were they using horses still?
- MARSH No, we had tractors, yes. And of course we had a car, but ... oh yes, the haystacks, you know, I can remember quite a lot.
- There was a flood. And the house was made of mud brick and I can remember everybody bogging in and filling up sandbags and sandbagging the creek off so that the house wouldn't be flooded and damage the foundations.
- HARTLEY So was that in mud bricks or was it built as a solid wall and rammed down.
- MARSH It could have been rammed down, I don't know. Well, I can remember it was mud, anyway.
- HARTLEY So how did you get to school?
- MARSH 18 We used to walk to school. Actually I didn't start school until after we left the farm. And first of all a neighbour allowed us to stay in one of his – he had a vacant house on his property – and there was a soak associated with it so we used to eat rabbits and grew vegetables on the soak. I can remember the rabbits screaming in the traps at night.
- HARTLEY Oh gosh!
- MARSH And then, we moved to a house in Harrismith itself and of course the walking to school was easy. And there until we moved up to Leonora and my father went to work in the meantime. My father used to do lumping, wheat lumping.
- HARTLEY They were very heavy wheat bags, weren't they?

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- MARSH Yes.
- HARTLEY Was he a big man?
- MARSH Yes, he was six foot three. He was a little bit taller than I was. I was six foot two and three-quarters. He was six foot three.
- HARTLEY Oh, you had it over him.
- MARSH Yes. No, he had it over me – a quarter of an inch!
- HARTLEY Oh.
- MARSH But he died in 1943. His rheumatic heart caught up with him. He'd set up a poultry farm gradually and sometime during the war he gave up working on the mines and we were full time poultry farming.
- HARTLEY So that was near Kalgoorlie, the farm?
- MARSH Yes.
- HARTLEY The poultry farm was in Kalgoorlie.
- MARSH 20 Yes, we were poultry farming in Kalgoorlie. During the war, it was a bit of a gold mine because the price of eggs was fixed and it was a very profitable enterprise. In fact, after my father died; my father died when I started university in 1943 and my brother, he carried on at high school, until the end of high school – that would have been two years later, 1944, he would have finished high school. My mother sold up the farm. My brother didn't want to sell up because he was looking after the poultry farm, you see.
- HARTLEY He was making a bit of money too
- MARSH Yes, well. The family was.
- HARTLEY You started school at Harrismith.
- MARSH Yes.
- HARTLEY Unofficially.
- MARSH Yes, unofficially, yes.
- HARTLEY So you first went officially in Kalgoorlie.
- MARSH Yes, North Kalgoorlie School.
- HARTLEY Primary school, was it?
- MARSH Yes, primary school. So I started on ... the dates are a bit confused somehow. I know I started in second class because I got credit for the ... I think, you know, in between the Harrowsmith and Kalgoorlie [schools] I think I can remember correspondence school so I had done correspondence somewhere. So I started in second class, which must have been 1932, I think, because I finished in 1937. Something like that.

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And then in 1938, I went to the Eastern Goldfields High School.

HARTLEY Were there a lot of primary schools in Kalgoorlie because other people that I have interviewed, they all went to North Kalgoorlie ? [laughter] Were there other ones?

MARSH 22 Well, I suppose so. It was a little school, because when we went to high school, I think they had 600 pupils and that seemed huge. So, yes.

HARTLEY That was when the high school was on the Boulder Road, was it

MARSH Yes, yes.

HARTLEY A very dusty location.

MARSH So I used to cycle to high school.

HARTLEY So whereabouts in Kalgoorlie did you live?

MARSH We lived in Lamington. We lived on Kyles Hill in Addis Street, 1A Addis Street. No. 1 Addis Street was Kyle's - he was the uncle of Wallace Kyle, the Governor. I think he was. And anyway, my father bought three-quarters of an acre from him down on the slope of the hill, so when we expanded the poultry farm after my father retired, we leased land from North Kalgurli mine for the poultry farm. Well, we had part of the poultry farm on the three-quarters of an acre. It was quite a big block.

HARTLEY Were they what they call free-range hens?

MARSH Free-range hens, yes. Yes.

HARTLEY What mines did your father work on?

MARSH 24 For a start he worked on the Old Associated Mine and that was retreating ore, retreating dumps. I think it included the Golden Horseshoe Dump. The Golden Horseshoe Dump had been huge. I think it was dominant. It was just a triangular peak and it dominated Kalgoorlie.

HARTLEY And Boulder too.

MARSH Have you heard of it?

HARTLEY Yes, oh yes. I have seen pictures of it.

MARSH Yes. And then Associated closed down and the same company opened up the Oroya South mine which treated its own ore and also it treated tributers' [ore] as they called them.

HARTLEY Oh yes.

MARSH And, during Christmas holidays I worked on both those mines.

HARTLEY Did you work in the assay office or something like that?

MARSH Yes, I worked in the assay office on the Oroya South.

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- HARTLEY So that was when you were at university. We are getting ahead a bit.
- MARSH I worked on the old Associated when I was still at high school and the Oroya South when I was at university, the first year university. The second year – it was during the war – we got manpowered.
- 26 When I started at university I was only just 17 but then once at university you were manpowered and anyway, so at the end of '43 I worked on the Oroya South. And '44 I went over to Melbourne and worked at Fisherman's Bend at the Commonwealth Aircraft Corporation.
- HARTLEY That must have been interesting.
- MARSH Yes, well, it might have been at the DAP, Department of Aircraft Production. I think the Commonwealth Aircraft Corporation was a private firm. Anyway, .. and they were making ...
- HARTLEY Wack---
- MARSH Beauforts.
- HARTLEY Beauforts, were they?
- MARSH Yes, Beaufort bombers. And CAC were making Wirraways, if I remember rightly. And, yes, so I worked there in my first year of experience.
- HARTLEY When you went to university, did you go on a scholarship?
- MARSH No, no. I didn't go on a scholarship. At that time, they had Commonwealth assistance and Commonwealth assistance just paid for everything, so I went to St Georges College and the fees were £90 a year but the Commonwealth scholarship paid £140 a year, so it was pretty generous. And, of course, it was after my father died.
- HARTLEY So was the tuition free? It used to be known as the free university.
- MARSH Yes, yes. Tuition free.
- HARTLEY It was all free then, was it?
- MARSH Yes, yes.
- HARTLEY When did it stop having free tuition?
- MARSH 28 I'm not sure when it stopped. It went on for many, many years, but I think gradually the fees came in. It wasn't a thing that happened overnight.
- HARTLEY It was a great thing for people who weren't very rich, wasn't it?
- MARSH Oh yes.
- HARTLEY So was there any teacher at school that inspired you for engineering or for maths and science?
- MARSH No, well I was always interested in all science subjects and I could have gone into any of them. Maths, I suppose, was my primary interest. I'd got four

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distinctions in my leaving and they were all in the maths subjects. Applied maths, maths, physics and chemistry.

HARTLEY There were not many high schools in that time, were there?

MARSH Pardon?

HARTLEY There were not many high schools in the state. Everyone knows Modern, Perth Modern ...

MARSH No, there was only one high school in Kalgoorlie then and that was Eastern Goldfields High School. There were only six boys in our final year. Thirteen girls and six boys.

HARTLEY Oh.

MARSH I imagine that a lot of boys would have turned 18 and they would have gone into the services.

HARTLEY 30 Yes, and ended up in Syria or somewhere like that.

MARSH Pardon?

HARTLEY I was thinking they went to Syria, that's where the Kalgoorlie soldiers ...

MARSH In Syria?

HARTLEY Yes.

MARSH Oh, I am not sure. They went to the air force and all that sort of thing.

HARTLEY So you lived at the St Georges College when you were at university?

MARSH Yes

HARTLEY And only went home in the holidays and worked at Kalgoorlie.

MARSH Yes, but my mother came down in '44, so that's why I went over east.

HARTLEY Oh yes.

MARSH She'd sold up and she came down in 1944. Yes, she sold up and my brother, for part of the year, he went to Mod - Modern School. Yes. She wanted to make sure he went to university.

So in 1945 I went to Cockatoo Island in the Christmas holidays.

HARTLEY Was it a four or five year course then?

MARSH It was a four year course.

HARTLEY So you didn't have the penultimate year which is supposed to be largely practical?

MARSH No.

HARTLEY No. That arrangement was just during the war, I suppose.

MARSH 32 Yes, that was just during the war. So, '45, that was my third year and I went up as a labourer, but got immediately employed as an engineer. And I got there on labourer's wages which were a lot better than a student's wages. They were short of engineers, of course.

End of Side A, Tape 1

Side B, Tape 1

Tape 1
Side B
minutes

HARTLEY 00 So Cockatoo Island was already operating as an iron ore deposit?

MARSH No, no. They were putting the infrastructure in .

HARTLEY Oh, yes. Because the other was Koolan Island?

MARSH No it was Cockatoo Island. Koolan Island hadn't been developed at that stage. The Japanese had investigated the iron ore before the war and they were interested in it, and BHP had acquired the leases.

HARTLEY So was that one of the reasons why the embargo was put on for exporting iron ore? Because the Japanese were interested in that?

MARSH 02 Yes, I imagine the embargo must have probably started round about when the war started, I guess. BHP was putting in the infrastructure. Most were living in tents and at that stage, there were cabins but they had just started on the mining infrastructure, building roads and putting in crusher foundations. And they had a little concrete jetty that was only usable at high tide or when the tide was up and I designed an extension of that jetty, which was good experience, and also with Ralph Lake, another engineer on work experience, we designed the sewerage system for the island as well.

HARTLEY How did you know where to start?

MARSH Pardon?

HARTLEY How did you know what to do?

MARSH Well, I guess we'd had that in our course. I mean the subjects we did at university included hydraulics and yes, all that sort of thing.

HARTLEY Oh yes.

MARSH In my course, I did very well. I got nine distinctions in all but I hadn't finished my thesis so I wasn't eligible for honours.

HARTLEY How ridiculous.

MARSH 04 Yes. We got very little supervision and I'd done a thesis which had involved experimental work on soil cements. Without the supervision, the experimental work extended a bit and so I ran out of time.

- HARTLEY Oh, that's unfortunate, isn't it.
- MARSH Yes.
- HARTLEY Wasn't your father a bit of an inventor as well?
- MARSH Oh yes. When he was farming in England in 1940, he invented a three wheeled steer and drive tractor for small plots, and Sankeys, the firm that subsequently got famous for making toilet bowls, made two prototypes, and my father got one of the prototypes which he used. I've got photographs of that around the place. But he was always inventing something and when he was on the mines he was – he taught himself mechanical drawing – I think he was a frustrated mechanical engineer – and he invented, I remember, an improvement to the Oliver filter.
- HARTLEY Oh really.
- MARSH Yes, but I don't know if anything ever came of that, but a prototype of that was made as well. But Sankeys never went on. The war intervened and they were going to put the thing into production but it never eventuated.
- HARTLEY Wasn't the kind that you make out of porcelain then?
- MARSH 06 [laughter] No. I guess these days you would look at ceramics, wouldn't you, with everything getting stronger and stronger.
- HARTLEY Yes. What made you decide to do civil work engineering, rather than mechanical?
- MARSH I don't really know. I went down to sign up for a university course and I had maths in mind – pure maths – but eventually I put down mechanical engineering. I guess it was my father's influence somehow or other. But the lecturer, he was a very poor lecturer, he wasn't at all inspiring and about all he knew was steam engines and so I switched to civil during the course.
- HARTLEY And who was the lecturer in that? That was the Professor ...?
- MARSH Blakey, Blakey was the lecturer then. Yes.
- HARTLEY He was quite an inspiring man.
- MARSH Yes, he was quite inspiring. Yes.
- HARTLEY He didn't let you finish your project on soil cements
- MARSH Oh well, I finished it, of course. I finished it later. I finished it during 1947. Of course, another thing too, I think it was in 1946 that I became interested in a girlfriend [laughs] which didn't help either. And we eventually married.
- HARTLEY What was her name?
- MARSH 08 Her name was Phyllis Morton. They were farming at Trayning, yes.
- HARTLEY Oh really?

MARSH She, at that stage, was already graduated and was teaching ... was a schoolteacher. Oh, she hadn't graduated. She had done a teacher training course and she was teaching at a little private school.

HARTLEY So when did you get married?

MARSH We got married in 1948.

HARTLEY That was after you joined the Main Roads?

MARSH Yes.

HARTLEY What year was that when you joined the Main Roads?

MARSH In February 1947 I joined the Main Roads.

HARTLEY What did you do to start with?

MARSH I started in just general road work and I first went out with the surveyor surveying the improvements to the road from Pinjarra to Dwellingup.

[TELEPHONE RINGING, PAUSE IN TAPE]

HARTLEY We are in business again now.

MARSH Okay, we are in business?

HARTLEY Yes. Surveying new routes through the hills?

MARSH 10 No, no, it was just an improvement, improving the old road - realignment and regrading, that sort of thing. The road works were going on there at the same time.

HARTLEY I think we will stop again because there is someone at the door for you.

[PAUSE IN TAPE]

Yes, you were working with a surveyor. Did you actually do the surveying.

MARSH Oh, yes, I would have assisted with the surveying. He would have given me a go on the instruments and that sort of thing, yes.

HARTLEY You camped out then with the Main Roads camp?

MARSH Yes, in a camp at Pinjarra. And it was very soon after - oh probably about three months, I think - when Godfrey, the bridge engineer, wanted another assistant.

HARTLEY That's Ernie Godfrey his name, isn't it?

MARSH Ernie Godfrey, yes. So I came back to head office. The first time in head office, rather. I went back to Perth anyway.

HARTLEY Where was the head office?

MARSH The Old Barracks, yes.

HARTLEY Oh.

MARSH 12 Then the work on the design of the Causeway was just proceeding at that stage. And Harold Malcolm was doing the detailed design under Ernie's supervision and I was engaged doing some checking of the design and also working on supervision of construction of timber bridges around Perth. The first one was the bridge at Guildford on the road going north from Guildford, not the main road.

HARTLEY Middle Swan, is it?

MARSH West Swan Road, I think it was called. So I was engaged in the supervision of that. That was my first experience of construction, I suppose, of bridges.

HARTLEY Did they have wooden trusses for the main spans?

MARSH No, no. The main spans were steel. It was a 40 foot navigation span.

HARTLEY Right.

MARSH And then there was another bridge at Gosnells somewhere, that I was involved with during those early periods, and then I went on to the construction of the Causeway commencing probably late '47 or early '48.

HARTLEY That was the timber piling, was it?

MARSH 14 It was timber piles, yes, and then concrete above that. And so that involved coffer dams with timber piles as sheeting.

HARTLEY Timber sheeting?

MARSH Timber sheeting, yes.

HARTLEY Oh. It was sort of tongue and groove, was it?

MARSH Sort of. It was called birdsmouth sheeting.

HARTLEY Oh yes.

MARSH They were karri, karri sheeting. The piles were karri because they were permanently below groundwater and protected by the soil so there was no problem with insect attack or rot.

HARTLEY So they had to be long piles to go into the mud?

MARSH Yes, I think they were as long as 20 metres. There were deep sediments there. But quite firm sediments. Well, you had to go quite a long way to get down to the firm stuff.

That bridge was interesting because of its composite construction, sixty-foot spans.

HARTLEY That's composite – steel beams with concrete on top.

MARSH Yes, with shear connectors, yes.

HARTLEY Was that one of the first in Australia?

MARSH 16 Oh, no, no. The technology had been started by Frank Knight, who was then in the Bridge Department of the Highways Department in Tasmania. Later, of course, he was quite famous because he went on to the hydro-electric in Tasmania. So he was a bit of an innovator, Frank Knight.

The construction was interesting because it was prestressed. Jacking beams were placed across between the piers and then after the girders were placed above and bolted down they were jacked up in the middle. And then the concrete was placed, the jacks were released, and the concrete deck went into compression. There had been a lot of problems with shrinkage cracking in composite construction and the prestress overcame this.

HARTLEY Was that in Victoria?

MARSH I am not sure that it occurred then but the composite construction became quite widespread, worldwide, and certainly later on they had a lot of trouble in Europe, probably not to start with, because most of this composite construction was built post-war on the reconstruction of bridges throughout Europe that had got destroyed during the war.

18 But anyway, the salting, the salt used when the weather was cold, to stop icing, of course got through the cracks and then rapidly corroded the steel. But I think the cracking problem was a problem with those early bridges, but certainly prestressing overcame the problem on the Causeway.

I'm not sure if this was the first to be prestressed or whether Knight had already built some like that, but I am not aware of any other ones that might have been built.

HARTLEY So it means you had to put a second layer of beams to pre-stress off. You had to have the jacking beams underneath the main steel.

MARSH Yes, yes. And then those jacking beams were floated around and put in the next bay or the next span.

HARTLEY Oh yes.

MARSH So it was simply supported. And it had expansion joints at each span. And of course there was a bit of a problem at expansion joints.

HARTLEY Yes

MARSH It was very difficult to prevent corrosion and subsequent problems.

HARTLEY Yes. What sort of concrete did you use? A special mix?

MARSH 20 The concrete was excellent concrete. Ernie used the US Bureau of Reclamation Concrete Handbook and they had a lot of experience, of course, and the recipe was there to make excellent concrete. Basically, coarse aggregate rich and cement rich mixes. Low water-cement ratio. And those mixes were resistant to cracking. They were mortar-lean mixes – difficult to work.

HARTLEY Yes, I was just going to ask you that.

- MARSH But when you worked them, they were excellent concrete. And so the concrete has stood the test of time on the piers, although at the waterline, they were covered with a bituminous paint to further protect them.
- HARTLEY What sort of concrete vibrators did you have in those days?
- MARSH They were internal concrete vibrators, yes, pneumatic vibrators. Very good vibrators. Yes, so the whole construction phase was very interesting.
- HARTLEY Did you have greater control when it was done by day labour than if it was done by contractors?
- MARSH Well, the supervision can be adequate with contractors as well, but of course we did all the setting out and all that, so construction management and supervision were fairly close.
- 22 So I had quite a lot to do. For instance, to try to get the construction tolerances down, we had ... I designed a system of longitudinal supports from end to end and so we could screed the concrete from these supports. We used army box girders for that because we had lots of army box girders.
- HARTLEY The steel was pretty hard to get hold of though, wasn't it, otherwise.
- MARSH We'd had some bad floods and some bridges had got washed out down south and we got all these army box girders and built temporary bridges with the army box girders and a lot of those temporary bridges had been replaced and we had stacks of army box girders – which were enormously useful for temporary works.
- HARTLEY There was a shortage of structural steel at that time, wasn't there?
- MARSH 24 Yes. Ernie doubled up on the orders of structural steel because the work was getting delayed. Also cement – we had cement from all over the world. We had cement from the east, we had cement from South Africa, we had cement from Sweden, we had cement from England. Yes, so we had cement from all over the world.
- HARTLEY The Public Works Department on Mundaring Weir, they had the same problem, running out of cement.
- MARSH Yes, yes. Some was high alkali cement and we were also at that stage very conscious of alkali aggregate reaction. I think Ernie was well before his time there and so whenever we'd do concrete work, wherever we did it, we would always conduct alkali aggregate reaction tests, both chemical and mortar bar tests to check for the expansive reaction.
- HARTLEY Not everyone did that in those days, did they?
- MARSH No, no. And also because no way were we going to have problems with our concrete with concrete cancer that's occurred all over the place due to too high a water content and not enough cement, which leads to carbonisation of the alkali which protects the reinforcement against corrosion.
- HARTLEY Where did Ernie Godfrey come from? What was his background?
- MARSH 26 His background was Victorian Railways.

- HARTLEY Oh, right. So they did a lot of bridge work.
- MARSH Yes. He came over in 1928 and immediately started building concrete bridges. He built a number of them until he realised that timber was a lot cheaper. [laughter]
- HARTLEY Well, I suppose in the northwest it probably was.
- MARSH Well, even as far north as Fitzroy Crossing, there was a timber bridge there. The De Grey River, there was a timber bridge there – single lane timber bridges. So that was in the 1930s when a lot of those timber bridges were built. But also some concrete bridges were built at the same time. J G Punch, who was later Commissioner here, he must have been engineer for the northwest or something or other, because he was responsible for building quite a number of these bridges up there.¹
- HARTLEY That's the Gascoyne Bridge and ones like that.
- MARSH 28 The Gascoyne Bridge was built by Brigadier Drake Brockman.
- HARTLEY Oh, wasn't he Engineer for the North-West?
- MARSH Yes. I'm not sure anyway, because Brigadier Drake Brockman was Public Works Department and Punch must have been working for the Public Works Department when those bridges were built. Anyway, he built them like that. Subsequently he was in Main Roads and became Commissioner.
- HARTLEY So what was Godfrey like to work with? You said that Godfrey was difficult to persuade to do new things.
- MARSH Difficult to persuade. He was very supportive mainly. I think he was pleased with what I did, but he was very hard to persuade when he'd made up his mind on something and I found that I could get around that by suggesting something and then coming up with an awful lot of reasons why it was no good. And then he'd produce this a few days later as his [laughter]. One thing I was never able to persuade him.
- 30 My first job by myself was the town bridge at Mandurah and I first of all designed that with batter piles in the piers and Ernie couldn't be persuaded to have a pile frame battered.
- HARTLEY He wanted them all vertical, did he?
- MARSH No, no. He'd apparently driven batter piles but with a vertical pile frame, which of course created a lot of problems. I couldn't persuade him that the sloping pile frame would overcome those problems, so they had to be designed with vertical piles.
- 31 But this bridge was started while the Causeway was still under construction in around about 1951.
- HARTLEY So when did the pre-cast, pre-stressed stuff come in?

¹ J. G. Punch was Main Roads Department Divisional Engineer at Carnarvon 1946-1951.

MARSH I think it was the early fifties. We were building a bridge somewhere in Geraldton. Well, we were about to and I was doing the design for this bridge and I wanted to use pre-stressed concrete for it. I think it was about 1953 and I couldn't persuade Ernie to do that. But later, Ernie employed an engineer, he was Australian but he was from England, Don Gratton-Wilson.

HARTLEY Oh yes.

End of Side B, Tape 1

Tape 2, Side A

Tape 2
Side A
minutes

MARSH 00 He had worked for a number of years for Samuelly mostly on buildings of pre-tensioned prestressed concrete.

HARTLEY And that's a British consulting engineer?

MARSH Yes. He was quite well known. So Gratton-Wilson designed the first pre-stressed concrete in WA – I think that would have been around about 1956 and the first one was Grey Street Bridge in Northam over the Avon and there they used pre-cast, pre-tensioned concrete. They were quite small spans, six metre spans. They must have had a steel navigation span, I think. And we set up the pre-casting beds at Northam and they remained at Northam and were used for quite a number of bridges around the state. They were inverted U beams with a shear joint. No they didn't have shear joints. They had a concrete topping to distribute the load.

HARTLEY What about the piles? Were the piles pre-stressed concrete as well?

MARSH Yes the piles were also pre-stressed concrete, yes. And then the first post-tension concrete bridge; well, I designed that and that was Axon Street Bridge in Subiaco.

HARTLEY Oh yes, is that over the railway?

MARSH And at that stage, Jim Leslie had joined us and Jim did the detailed design and that used a Freysinnet system.

HARTLEY That was over the railway?

MARSH 03 Over the railway, yes. The main span was pre-stressed concrete. The smaller side spans were in-situ reinforced concrete.

Prior to that time we had started to go into pre-cast concrete for bridges, small span pre-cast concrete bridges and that involved inverted U beams but they were connected by a moment and shear joint. And so they didn't have concrete topping.

HARTLEY Oh, didn't they?

MARSH Quite a number of those were built around the country.

HARTLEY So in the gap between the two U beams you had shear connectors there.

MARSH Yes, there [sketching a diagram] were overlapping hooks in the joint.

HARTLEY Oh yes.

MARSH 05 And then that was just filled in with a strong mortar with a bit of aggregate in it, but they were big enough to consolidate thoroughly.

HARTLEY And you put bitumen over the top?

MARSH Yes, and then there was just two inches of bitumen on the top.

Oh yes, around about, in the fifties as well, we began topping the older timber bridges – well, even the newer ones – with concrete. Actually, the early ones, we took the old deck off and cast-concreted across, but later ones we simply left the deck there and cast concrete over the top, which preserved the deck.

06 The first one of these, the first concrete deck on a timber bridge was Kerr Street [Hamilton Street] bridge over the railway in Subiaco, or West Perth – Subiaco.

Then, also we built quite a number of timber bridges on round timber with concrete decks and although I don't think we ever ... we'd drive a lot of spikes which actually would have acted as shear connectors in the strength of the thing. I don't think we ever made use of the shear connectors in the design.

HARTLEY So you didn't have a composite timber and concrete bridge?

MARSH No. I don't think we ever used them as a composite, although they would have acted compositely.

First of all, when we first started using these we'd put a joint every 3 spans, that is metres but then later we realised that we didn't need to do that so we'd make the concrete continuous but over the piers we'd just make a joint which could open up and put in a sealant in that because, of course, you'd get a lot of rotational movement in the timber bridges.

HARTLEY Yes.

MARSH 08 Do you know John Pressley?

HARTLEY Yes, I know the name, yes.

MARSH Yes. I think John Pressley claims credit for putting concrete over the timber deck of a timber bridge. I am not sure if that is right or not, but anyway ... [laughter]

HARTLEY Well, it protected a lot of timber decking bridges, I guess.

MARSH Yes, oh yes. It extended their life enormously. Piles of course were always a problem and a lot of the piles have tended to rot at ground level, just below ground level, in the wet and dry. If you look underneath, you will see there's concrete at dirt level where a concrete connection has been made where the rotted bit has been cut out and concrete cast to keep the bridge going. You will see that on a lot of bridges.

- 10 The oldest bridge in the state incidentally, that's been protected, has still got its original timber deck with a concrete topping over it. It was one of the bridges built by the convicts in 1864 on a side road over the Greenough River. I forget the name of the road, but when we put the concrete topping on the original deck, probably in the 1960s, it would have been almost a 100 years after it was built.

HARTLEY Good heavens. Was that the one with the stone piers?

MARSH Oh yes. A lot were built with stone piers.

HARTLEY Maley's Bridge, I think, was it?

MARSH Pardon?

HARTLEY Maley's Bridge.

MARSH It wasn't Maley. I think I would recognize the name.

HARTLEY No.

MARSH Yes, so we spent a lot of time on extending the life of these concrete bridges. Peter Palmer was looking after the maintenance during this early period.

HARTLEY When did you start using ready-mix trucks?

MARSH The first ready-mix was on a bridge in the Kimberley, I think it was. Yes, we built some cast in place bridges. In fact, in the late 50s, we found that the cast in place was cheaper than timber.

- 12 I guess the economics would change from time to time, but the key to this was the contractor had acquired a ready-mix truck. There were no ready-mix firms. They had acquired a ready-mix truck and set up in the Kimberley, using this ready-mix truck from a centralised plant, so it was an early application of ready-mix concrete. And that set-up was used to build two or three bridges on the Great Northern Highway, south of Wyndham. The concrete was transported I think up to about 12 miles if I remember rightly.

One of them was over McPhee Creek. Shortly after it was built, the creek had a massive flood and ... we had photos of this bridge with huge logs built up against it, you know, boabs and things, so it became a dam but it withstood the dam alright.

HARTLEY Oh, did it?

MARSH Yes So these bridges were built between Halls Creek and Kununurra. There were a few bridges we built, and that was the first ready-mix concrete.

HARTLEY How did they get the ready-mix truck up there?

MARSH They drove it up.

HARTLEY Oh.

MARSH Yes.

HARTLEY How much bridge work was done by contractors in the 1950s?

MARSH Actually, quite a lot. We also did a lot of the northern stuff by direct labour. I just can't remember, but from time to time, you know, governments had changed and we would do more contract work. The first large contract work we did was the ... well, since the 1930s, was the Narrows Bridge. And work commenced on that in 1957 or early '58 – I forget now – probably early '58.

- 16 Ernie Godfrey in the early 1950s, well 1954, I think it was, was starting looking at the new bridge for the Narrows and Ernie designed or proposed a bridge with 130 foot spans composite, similar to the Causeway construction, and Harold Malcolm began designing that and at some stage during this period Leach intervened and said, no, we are going to get consultants to do it.

So Ernie went off on an international tour to engage consultants and to look at bridges around the place. Well, Europe, I think he went to. I don't think he went to America. But he went around Europe. And during this period he of course interviewed Freeman Fox and also Maunsell Posford and Pavry and some others ... yes, other prominent consultants.

- 18 But most of them wouldn't tell Ernie what they proposed to do. But Maunsells were quite ready to do that and produce some preliminary ideas, so they were eventually employed. And while they were waiting for construction to start, they employed two young engineers and they were seconded to me pending start of construction. So that was Jim Leslie and Geof Fernie.

HARTLEY Did they ever consider other types of bridges like suspension bridges for the Narrows?

MARSH Look I imagine that the number of alternatives were looked at but I think their recommended design was the one that was put in. They certainly would have looked at alternatives but I don't remember them.

So the design was done in England and then when construction started, Ernie was full time liaison and I became Acting Bridge Engineer.

[break in tape]

HARTLEY 20 Okay, we are in business again now.

MARSH So Jim Leslie and Geof Fernie were seconded to me and helped with investigations and Geof probably started work with Maunsells before Jim. I am not sure. Not sure which way it went. Anyway, Geof started later, but as I mentioned before, Jim did the detailed design for the Axon Street Bridge.

HARTLEY I think Geof graduated a year before Jim.

MARSH I see. I don't know, anyway for some reason or other, Jim went on to that design. I don't think Geof did any design with me. So that was the Narrows Bridge.

I had undertaken the foundation investigation for the Narrows Bridge so I got fairly familiar with the soil and also I'd been looking after Main Roads' interest in the Mounts Bay reclamation works.

- 22 Norm Henry, Engineer for Harbour Works, did the reclamation for the approaches to the Narrows Bridge and I'd been monitoring the settlements. It was reclaimed with mud. Around the periphery it had timber sheet piling to retain it, except in the Narrows Bridge area where it was probably just a dirt bank. The mud was allowed to dry out for a summer and then it was topped with 1.2 metres of sand. I was monitoring the settlement on that whole area.

It must have been during that same period as well, we displaced the mud at the northern end for the northern approaches to the Narrows Bridge with sand, so I was looking after that work. And we aimed to ... [draws a diagram] you've got Mounts Bay going around, and the reclamation was proceeding in here, or the sand covering was being pumped on.

HARTLEY Yes.

MARSH And we started displacing mud out this way so that the slip circle went out in that direction. The object was to get nearly complete displacement under the Narrows Bridge alignment.

HARTLEY So what was the depth of that?

MARSH The depth of the mud was 18 metres and the strength of the mud was mostly only half a pound a square inch. It's very sloppy mud, weak mud.

- 25 We achieved our objectives there. We kept monitoring the displacements. We found there was a bit of a pocket of mud on one side here, so we put in a small charge of explosives there to get rid of it. And all we succeeded in doing was re-activating the slip circle containing the displacing sand moving some 200,000 cubic yards of this sand about six feet. We didn't realise at the time – well, we did soon realise it because the astronomer – what was his name, Spiegel, put out a call for any information which would lead him to determine the epicenter of this earthquake. [laughter]

And so there was some cracking in houses about the Mounts Bay Road, but not realising what was going on, we denied responsibility, until we realised what had happened.

HARTLEY So that big pile of sand was moved.

MARSH 27 Yes. The displacement was reasonably successful because the settlements at the junction of the bridge, or the bridge abutment and the bridge, was limited to maybe about 60cm or something like that. I don't even know if there's been that much. But I think a couple of times the approaches have been built up level but the settlements are very slow. But of course, below this, you've got firm Eocene clays and with the enormous weight of sand above it. We expected a certain amount of settlement anyway.

HARTLEY Long term settlement.

MARSH Yes, well even hydro dynamic settlement in this would take a number of years. So yes, it would be long term settlement. The secondary settlement in this stuff wouldn't be as high as in the mud, the highly organic stuff, you get a lot more secondary consolidation.

HARTLEY What were you thinking of the abutment foundations then?

MARSH For the Narrows?

HARTLEY Yes, for the bridge.

MARSH Well, Maunsells put in a ... they had a box type of abutment with the bridge coming out here. It was a hollow box, with the concrete on the top. There is a deck on the top, but of course ... so at the back of that, that's where you have got the differential settlement, at the back of that abutment, which is quite big. It's a hollow box structure.

HARTLEY 29 What were the piles underneath?

MARSH The piles were steel, they were tubular steel piles. It was while we were monitoring the settlement of this area, if you imagine the bridge going in that direction, we found that the settlements from here where there's virtually no mud left to well out into the river was basically increasing almost linearly. So you've got your increasing settlement.

30 So you've got increasing settlement here below this sand which is, therefore, tending to rotate about the point where the mud has been completely displaced and it's got a horizontal component. So as soon as I realised this – Maunsells were still designing – I drew their attention to it and with the result that these piles in the abutment and also the first pier were put into an annulus—that is in a tube isolating each pile from, the surrounding soil.

HARTLEY I see, so the gap between the inner pier and the other one.

MARSH 31 Yes, and it seemed to me that we were going to get something like 10 inches of horizontal movement.

HARTLEY That's a lot.

MARSH Maunsells did their own analysis and, anyway, they allowed 12 inches of annulus.

HARTLEY So why were they called Gambia piles. I have read somewhere quite often they say that they are using Gambia piles. What does that mean?

MARSH Well, Gambia piles were closed ended cylinders and they were driven with a drop hammer down the bottom and Maunsells first used them on a bridge in Gambia.

HARTLEY Oh, hence the name!

MARSH Or a wharf in Gambia, I forget which.

HARTLEY Oh.

End of Side A, Tape 2***Side B, Tape 2***

Tape 2
Side B
minutes

- MARSH 00 The drop hammer is hitting right down the bottom and so the blow is very efficient. The piles had a bit of concrete in the bottom to spread the load to the steel. Christiani and Neilsen used a ten ton drop hammer.
- HARTLEY When did you start working out what to do with the rest of the mud on the approaches to the bridge?
- MARSH Oh yes. The consultants for the Perth section of the Mitchell Freeway – I think they'd hoped to get the Narrows Interchange structures but we didn't really think very much of them as bridge designers of . But their proposal was to build a concrete jungle out there, with bridges. They hadn't considered stabilising the work.
- HARTLEY That was De Leuw Cather, was it?
- MARSH 02 De Leuw Cather, yes. They weren't really bridge designers. The Main Roads had engaged them because of their expertise in road design – geometric design for freeways and that sort of thing. And we learned a lot from them. They had us buy our first computer ... the first computer in WA as well – which was immensely useful.
- HARTLEY Really. So the Main Roads had the first computer?
- MARSH And I reckoned that we could stabilise this material with sand drains, and I had support from the commissioners and so ...
- HARTLEY So how did the sand drains work to consolidate the material they were in?
- MARSH I had looked at this and figured out that sand drains at 3 metre centres would do the job. They were on a triangular grid so the maximum drainage was from the centre of the triangle to the periphery of a sand drain, ie less than 1.5 m, instead of the maximum path, from the centre of the deposit to the surface and to permeable strata down below, ie about 10 metres. And so what would have taken 20 or 30 years, I reckoned could be achieved in 18 months.
- HARTLEY Oh wow. So where does the water go through once its in the drain?
- MARSH 04 It comes up to the surface and simply runs away. You've got the layer of sand on the top of the mud. It would just percolate away through the layer of sand. And the alternatives were to ... well the method of construction proposed – all this sort of came up later on – the actual method was simply to displace the mud with a closed ended tube which would create an area of disturbance around the tube, fill it with sand and withdraw the tube, and leave a column of sand in the mud. The disturbance layer is about one diameter so it is quite appreciable, and also the disturbance tends to decrease the permeability of the mud. And so that was looked at.

- HARTLEY So you actually drive it down the pile? Do you actually drive that or does it fall under its own weight?
- MARSH Well, the tube for a start would just go down under its own weight. It's hollow, mind you, so it would soon float.
- HARTLEY Yes.
- MARSH And so then it's driven down, but to do that you just put a weight on top – phoosh! Away it goes! [laughter] But, anyway, I will come back to that, but I went to England with the Gledden Scholarship, but, shall I continue with the sand draining?
- HARTLEY Yes. Go ahead.
- MARSH 06 Well, we conducted a test pile area, a test area, a test draining area which was quite large. I forget how big it was. So that it could be loaded, so the load would be effective, the constant load would be effective over the whole depth, so we had to sand drain quite a considerable area. Then that was test loaded with sand to maybe three or four metres – something like that, I think it was – to test the effectiveness of the sand drains, so the settlement and pore pressures were monitored over the full depth of the mud.
- HARTLEY So how do you measure pore pressure in a mud that deep?
- MARSH You put down a bore and put in a porous pot with a tube connection to a pressure meter and so these were put down at different depths and the hole back filled with impermeable mud, I guess, or something like that. Some impermeable material. And the whole thing was linked up to an area with a lot of pressure meters inside, inside a little house and automatic recordings made.
- 08 So when the mud is loaded up, the first pressure you get is actually the weight of the sand, because the internal construction of the mud is so soft so that its immediately responsive to the full load.
- HARTLEY Good heavens.
- MARSH And so then you measure the pressure dissipation and it worked out according to Hoyle. But the Professor of Civil Engineering at Manchester University was out at one stage and he came down and was interested, and he was quite convinced that we would have horizontal drainage layers which would speed up the process. So I was a bit concerned then about this area of disturbance so the method of putting the piles in was going to be important. The fact that the pore pressure appeared to be conforming to Hoyle, it could have been partly due to, if there were drainage layers, they could have been destroyed to some extent and this area could have been leading to the result.
- 10 So we did extensive testing of specimens cut from the bores in both directions so we could load up specimens in each direction. So specimens in this direction we'd look closely for drainage layers and of course the mud had been put down very slowly so drainage layers would have been close together anyway.
- HARTLEY Yes.

- MARSH But, closer inspection, microscopic inspection of this mud, we couldn't see any evidence of layers, and testing this way showed no difference in layers. And also the consolidation behaviour of the original area was no different close to the periphery as it was to the centre of the reclaimed area. And so the whole indication was that the mud was completely uniform. So eventually we went ahead, because the construction of the sand drains was going to be a lot easier with this method of just driving closed ended tubes, rather than jetting mud out, which was an alternative that had been used in the Netherlands to quite some degree. The thing about the jetting is that you don't have to have a tube because the pressure of the water is normally enough to hold the mud at bay and so you just jet the tubes.
- 12 But then, when we looked at the disposal of the mud jetted out which was going to be a fairly expensive. And also the normal method of constructing sand drains in soft mud like this, internationally, was to enclose the top of the tube in some sort of pressurisation device, so you could pressurise that, and then you can feed sand into the hollow tube. So you keep the mud out from the bottom while you fill. You drive the tube, pressurise, and then when you withdraw the tube, you'd feed sand down under pressure, because if you just fed sand down and then tried to withdraw the tube, it would immediately arch.
- HARTLEY Oh yes
- MARSHt On our test to overcome arching without pressurising, all we had done was saturate the sand, withdraw the tube, and as soon as that occurs, water starts to run out at the bottom of the sand and carries the sand with it. And that was very cheap. But I couldn't understand why this method hadn't been used before. I couldn't read anywhere in the literature that all you had to do was saturate the sand.²
- HARTLEY Yes.
- MARSH 14 So it made the sand draining cheaper than anywhere else we had read in the literature.
- HARTLEY How long do you have to on putting the sand into the tube?
- MARSH Only once.
- HARTLEY Only once, yes.
- MARSH Yes.
- HARTLEY When as you lift the tube up, you don't have to put any more in.
- MARSH You put water in as you fill the tube with sand so the whole mass is saturated. You withdraw the tube and you leave a column of sand.
- HARTLEY Right. Then the water starts coming up the sand.

² The order of sentences in this paragraph was rearranged by Mr Marsh on the transcript draft to assist comprehension.

- MARSH Yes. I imagine consolidation would commence immediately because the consolidation from the weight of four feet of sand onto the additional mud used in reclamation had barely taken place.
- I was also concerned about secondary consolidation and we engaged an engineer from Imperial College to advise us on this. We had done a lot of testing on secondary consolidation as well and we'd figured out that we were going to get, after the hydrodynamic phase, about 60 centimetres of secondary consolidation.
- HARTLEY 16 Over what period would that be?
- MARSH Pardon?
- HARTLEY Over what period would the secondary be? 10 years or 20 years?
- MARSH No, no. Oh you mean the secondary consolidation?
- HARTLEY Yes.
- MARSH Forever. And decreasing, it's exponential, it's exponentially decreasing. But I imagine that the first major adjustment of the approach level to the bridges on the Narrows Interchange occurred about 10 years after the construction and that was about 30 centimetres and I don't know if there has been another major adjustment since then. There would have been an initial small adjustment as settlement occurred over a short distance so that the traffic could negotiate it without too much of a bump. Then no major adjustment occurred. So the next 30 cm would take about 100 years or something.
- HARTLEY Well, we won't wait to see that. So how many sand drains altogether were put in? Hundreds or thousands?
- MARSH There were 38,000.
- HARTLEY Were there really?
- MARSH Something like that. It's in the literature, anyway.
- HARTLEY They were put in before the sand was put on the top?
- MARSH 18 Oh yes, yes. And then the sand was put on and then the whole area was closely monitored. Not only vertical settlements but horizontal settlements were also monitored over the whole area because you've got this big area and you are bound to get some three dimensional consolidation, some horizontal consolidation as well as the vertical. And that was something we were concerned about. We were concerned about that of course for the foundations of the bridges and so we had estimates of the horizontal consolidation, secondary consolidation as well as the vertical consolidation, from the consultants from Imperial College. And the maximum horizontal consolidation was determined to be in the vicinity of the carpark below the city – what do they call it?
- HARTLEY No. 2 Carpark.
- MARSH Yes, the Foreshore Carpark, and what had been the Foreshore Carpark, and there they'd estimated about 30cm maximum horizontal consolidation,

Elsewhere it was going to be much smaller, maybe 75mm. But in any case the horizontal movement led to the use of the caissons in the Narrows Interchange bridges.

HARTLEY 20 So the caissons for the Narrows Interchange Bridges, were they articulated to allow for that movement?

MARSH Oh yes, yes.

HARTLEY How did they do that?

MARSH They were designed with Teflon joints. So each segment was about three metres high and it allowed the appropriate annulus around the columns inside. And so each segment was about three metres high with Teflon joints so one could slide over the other. And of course they were designed for the amount of differential consolidation that you are going to get within the size of the segment itself.

HARTLEY So all the caissons would have to have this articulation, would they?

MARSH Yes. The alternative we looked at was steel sheet piling as a permanent surround but we also looked at maybe piles that could withstand three inches horizontal movement, but the mud under the weight of the load was going to finish up quite a stiff clay. It was going to finish up with the strength of instead of half a pound a square inch, it was going to finish up with the strength of twenty pounds a square inch, which is getting on to a stiff clay.

22 We couldn't come up with a design which would really adequately withstand that sort of movement and so that's why I went for the segmental construction.

And the steel piles might have been all right but the long term life of those piles ... the other thing was I had a test carried out, which Geoff Smith carried out, where we put in four boring rods with inserts of the steel that might be used for structural purposes, and then these were extracted and these were weighed for weight loss. That showed that the corrosion in the mud was going to be quite a problem. We also determined that the attack on the concrete was not going to be insignificant, and so all the concrete in contact with the mud was built with low alkali cement. It also had fine grain silica put in so that it was high sulphate resistant cement.

HARTLEY So that was because of the organic content of the mud.

MARSH 24 Well, no. It was due to the sulphate content of the mud and the mud contained anaerobic bacteria which converted any sulphate – and of course there is always sulphate in the water coming down from the inland – converted it to sulphide. And then the oxidation of the sulphide oxidized to sulphuric acid. And so that's what attacked the steel, and also it attacks the concrete.

I was aware of the desulphuricans, the bacteria that do all this work. So you have sulphur oxidising bacteria and sulphur reducing bacteria, both of them in the mud and I was aware of that because of the way bitumen was attacked in salt lakes in the country.

HARTLEY Oh yes.

MARSH 26 And these bacteria use the bitumen as a source of energy to carry out the oxidising and the reduction processes. So I was aware of that and so I thought that those bacteria are likely to be in the mud. And they were.

We also put in complete small diameter piles to test for negative friction. One was coated with bitumen to see if it would reduce the negative friction – a technique sometimes used elsewhere. As expected the bacteria consumed the bitumen and the load on that pile finished up the same as the uncoated one.³

HARTLEY Oh dear.

Now before all this was completed, you went to the UK on the Gledden Scholarship, wasn't it, to investigate this?

MARSH Yes, yes. I got a Gledden Scholarship.

HARTLEY What year was that?

MARSH 28 Well, I think I applied for it in '59. I thought I went away in 1961, but somebody said while I was away in 1962. I am pretty sure it was '61 I was away. It must have been '61 because I would have got the scholarship in 1960 sometime. So I would have gone to England at the end of '60 and came away at the ... oh, that's right I came back at the beginning of '62. Yes. I had two winters there. That was more than enough.

HARTLEY That was well timed.

MARSH And I had advice that I ought to go to consultants and contractors which I started off doing and with the object of getting. Well, there were two objectives. One was to gain some experience in the consolidation and stabilization of soils and the other was to get some experience in the design of large bridges, with all the work that was coming up in view. First of all I went to Wimpey's Soil Lab out at – you told me the name of the place – where is it? Didn't Maunsells have an office out there?

HARTLEY Yes, its out towards Mill Hill somewhere. I think its northwest London.

MARSH 30 No, no. This was alongside the railway somewhere west of London. Anyway, it doesn't matter. So I was at their soil lab for a few weeks and it was a very useful experience, with their methods of soil investigation.

HARTLEY What soil problems were they looking at?

MARSH They were largely engaged by the construction industry. Wimpeys were all over the place. Then after that I went to Maunsells and did preliminary designs for Middle Harbour Bridge in Sydney.

HARTLEY Oh yes.

MARSH And there I looked at cable stayed bridges; I looked at a concrete truss. I looked at concrete box girder bridges, of course.

³ This paragraph was revised by Mr Marsh on the transcript draft.

End of Side B, Tape 2***Side A, Tape 3***

Tape 3
Side A
minutes

MARSH 00 And then I went to a soils conference in Paris and met Professor Skempton. He was the guy in charge of the engineering side of Imperial College, and he suggested I went and did a half session with them. Well I did, and I was sorry I hadn't done the full session because it was very useful.

And while I was there I toured Europe and looked at concrete bridges all over Europe and – well, not only concrete bridges, large bridges all over Europe.

So it was a very profitable period.

HARTLEY So what courses did you do at Imperial College?

MARSH At Imperial College, I did their soils course and I also, under Munro, did their course on [pause] shell structures.

HARTLEY Folded plates, was it?

MARSH 02 Not only folded plates, it was curved structures as well. Anyway plate and shell theory. It was the mathematics of that process I was looking at.

And while I was there I wrote a programme for the analysis of box girder bridges and tried to get it on the London University computer before I left but didn't quite make it. So when I came back Ken Michael and I – well Ken did the programming on the Bendix computer for this box girder analysis– for the design of box girder bridges and we published the work in some NAASRA Proceedings that I have got there.⁴

HARTLEY While you were at Wimpeys, you mentioned that you went to Northern Ireland for something. What was that?

MARSH Oh yes. When I was about to leave, they said would I mind staying on for another fortnight and going over and sorting out a foundation problem they'd got over there. They were building a factory for Courtaulds.

HARTLEY Oh yes. The textile people.

MARSH And they had a two hundred acre site there. But the Courtaulds factory was taking up ten acres and in that ten acre site, they had only one bore.

HARTLEY [laughs] That's optimistic!

MARSH Yes. And where they were doing the actual construction work, when I went over to find out what was going on, it bore no relation to what was in the bore. [laughter]. And so their settlements were proceeding at a much faster rate than expected. I forget what we did to solve the problem, whether it was some preloading or something like that, probably for the rest of the site.

⁴ Contained in the list of Mr Marsh's publications

HARTLEY 05 The culture on site was slightly unexpected. We will have a pause now, there is a gentleman outside.

[Pause in tape]

Interview continued on 29th January 2009

HARTLEY 06 This is Richard Hartley, speaking with Gilbert Marsh on Thursday, 29th January, continuing our interview.

We are just going to talk about some of your family first before you get back onto the Main Roads. You were married in 1948, was it?

MARSH 1948, yes. December 1948.

HARTLEY Phyllis Morton?

MARSH Phyllis Morton, yes.

HARTLEY And she was a farmer's daughter.

MARSH A farmer's daughter, yes.

HARTLEY Where did you meet her?

MARSH I met her at university.

HARTLEY Where did you live after you got married?

MARSH First of all, we lived in a little flat, part of a house, overlooking the river in South Perth, which was very nice.

07 And then we moved to Subiaco and to a large house, and I guess after my daughter was born – she was born in 1953 - then in 1956, I built in Mt Pleasant and stayed there until 1996.

HARTLEY What is your daughter's name?

MARSH My daughter's name? Alison Margaret Marsh. She's a clinical psychologist. She started off teaching and then went back and did her PhD.

HARTLEY And works in ...

MARSH 08 She works in Perth, yes.

HARTLEY And you have a son?

MARSH A son? Yes, he has some problems. He was schizophrenic. It was not apparent until he was 24. But he did a journalistic degree at Murdoch but he has been very active in the mental health field and he was on Kierath's mental health task force and was responsible for a lot of changes that went into the mental health legislation. The 1962 legislation scored 4% on the United Nations' Charter of Human Rights.

HARTLEY [laughs] You can't get much lower than that, can you?

- MARSH 09 No. And the best in Australia was the New South Wales legislation which scored 56% while the WA legislation now scores about the same as the New South Wales one.
- HARTLEY We are catching up a bit.
- MARSH Yes, and he is on two Commonwealth committees on mental health. But he finds it very difficult to hold down a steady job, so he has got a low stress job - he cleans schools.
- HARTLEY A good steady job.
- MARSH Yes.
- HARTLEY So you moved from Mt Pleasant. Was that after your wife died?
- MARSH Oh no, it was 1956 we moved there. She died in 1994.
- HARTLEY Oh. Was it a long illness?
- MARSH 10 No, no. Very, very short. She had a stroke. We had a tandem. We were just going out for a tandem ride and she just dropped with a stroke, and died two days later.
- HARTLEY Gosh.
- MARSH She had lost her swallowing reflex and all sorts of things like that and she wouldn't have wanted to go on living, that's for sure. I stayed there for two years and then came down here in 1996.
- HARTLEY It's a nice convenient place to live.
- MARSH Very convenient, yes. It is, Richard.
- HARTLEY 11 Wasn't it built by an architect friend of yours?
- MARSH Yes. This place was built by Gerard McCann.
- HARTLEY Yes.
- MARSH But he was in some small developments with my son-in-law who is a doctor, Alison's husband, and they wanted a fifth partner in this development and so they persuaded me to sell up in Mt Pleasant, which was probably a good thing. I miss the garden a bit.
- HARTLEY Yes. Well, you've got a much bigger garden now. The whole of Western Australia.
- MARSH 12 Yes, that's right.
- HARTLEY One of your recreational interests, how did you get involved in rowing? At university?
- MARSH Yes, at university. I was in the university rowing team and also the St George's College rowing team.

- HARTLEY Yes, the St George's College was a hotbed of rowing, wasn't it?
- MARSH Yes. So then I got selected for the King's Cup in 1948. We rowed in Tasmania. We came second.
- HARTLEY Oh. Where did you row in Tasmania?
- MARSH On the Derwent.
- HARTLEY Oh, gosh, that's almost as big as the Swan.
- MARSH 13 Yes, yes. That was the problem. There was some swells coming up the Derwent and No. 5 caught a crab at the two mile mark, which didn't help our chances.
- HARTLEY Oh no, oh dear.
- MARSH We were only just beaten, even then.
- HARTLEY You recovered again, and came second.
- MARSH Oh yes, we were two lengths behind, we were only a canvas behind the winner at the finish.
- HARTLEY Oh really?
- MARSH Yes. We had been leading by two or three lengths before that.
- HARTLEY What sort of training did you do for the King's Cup? Did they put you through special ...
- MARSH Oh we trained endlessly. We were by far the fittest crew. George Orgill was a fitness man. He was the coach. And we rowed a thousand miles in training.
- HARTLEY That seems an awful lot.
- MARSH 14 Yes. During the summer months as well. We rowed in April in Tasmania.
- HARTLEY So did you do that early in the morning?
- MARSH Yes, early in the morning, yes. Lovely on the river, early in the morning.
- HARTLEY It certainly wakes you up, I should think, too. He was a well known coach, was he? George Orgill?
- MARSH Orgill.
- HARTLEY How do you spell it?
- MARSH ORG ... I forget how you spell it. He was a dentist.
- HARTLEY He was a well know coach.
- MARSH Yes, yes. And Carrick was the cox.
- HARTLEY You didn't feel tempted to follow up that rowing?

- MARSH 15 No, well, I would have liked to but I rowed through 1949 but it's seven days a week and it just doesn't fit in with family life.
- HARTLEY Well, nowadays, they do it for a long time, don't they, professional rowers. They become professional.
- MARSH Oh, yes, I played football as well.
- HARTLEY Did you?
- MARSH 16 I played for Mandurah at one stage, actually when I came down to Perth from Kalgoorlie. I'd been playing with one of the Kalgoorlie teams – it was during the war – there were four Kalgoorlie teams. Oh, I forget the names.
- HARTLEY Railways, is one of them anyway.
- MARSH Yes. So when I came down to Perth, I signed up with Subiaco but never played because I took up rowing. And when we were building the bridge at Mandurah, I played with Mandurah, in the Hills Association it was, for a couple of years.
- HARTLEY And I believe you are also a good tennis player too.
- MARSH Yes, well, tennis was a bit of a side interest. Well, I used to play regularly, of course. I used to play in the competitions but not at a very high level, but then after I retired I played in the over-70s. And then, I generally only played when they played in Perth, and I think I played in the over 75s. I played in the over 80s in Adelaide and played in the over 80s here. I haven't played for the last couple of years now. It wasn't worth it – the arthritis in the feet.
- HARTLEY Oh dear. That's marvelous to be able to play when you are over 80. It's phenomenal.
- MARSH 18 When I played in Mandurah, there was a funny incident, yes. The captain of the Pinjarra team had been a policeman in Mandurah and he was a nasty piece of work, and he used to encourage the young guys to drink and then he would beat them up for drinking! And because of the problems, they transferred him to Pinjarra and we had a young, very promising footballer, who played for South Fremantle subsequently – one of the number of brothers from Mandurah, and he was sixteen. And this nasty piece of work was captain/coach and he started to put the dirt into this young guy, and, you know hammering around there, and we had a guy, a fisherman, who was all bone. So we shifted this guy on to put the dirt into the policeman, and so the policeman moved himself somewhere else on the field and we shifted him over on to this and then the policeman turned around and arrested him for assault in the middle of the match! [laughter] Anyway, the sergeant was there and the sergeant told him not to be such a bloody fool! [laughter]
- HARTLEY I thought that only happened these days.
- MARSH Yes.
- HARTLEY We will get back to the Narrows Interchange Bridges if we may.
- MARSH Yes.

HARTLEY You mentioned something about the tolerances and locations of piers. That was a bit of a problem at one time.

MARSH 20 Yes.

HARTLEY What was that?

MARSH Well, in the sinking some of the caissons went badly out of tolerance. The tolerance we had was nine inches – whatever that is now, 25 cm, I suppose. Anyway, and some of them were over a foot over tolerance.

HARTLEY Wow that's a long way.

MARSH Well, one in particular, and the usual method of correcting those is to either prop as it is sinking and push it over as the sinking occurs or to put kentledge on to the opposite side and so they did that.

HARTLEY Kentledge meaning heavy weights.

MARSH Yes, kentledge, it was rails mainly. That's what they used. Tons of rails. And so they had all this kentledge stacked up and the props and nothing would work. It kept on sinking out of tolerance. So they stopped work. And wouldn't work until they were told what to do.

HARTLEY This is the contractor.

MARSH Yes.

HARTLEY Who was that?

MARSH 22 Yes, well, I don't know whether we should have told them what to do, but we did. So Peter Samuel came up with this idea of a lever attached to a drum, a small drum, and around the drum was a wire rope that was circled around the caisson and back and then the lever was loaded up with kentledge. And so we were able to put a constant force. Well, I mean, we discussed the matter and decided, you know, we had to put a constant force on the thing, and then that's when Peter came up with this idea.

HARTLEY So the cable went the whole way around the caisson?

MARSH Yes. And it worked extraordinarily well. In fact, in sinking the caisson four feet, it came right back onto tolerance. Just four feet. And it was remarkable. So I guess that was a first. We had never seen anything like that in the literature anywhere.

HARTLEY Who was the contractor then? Citra, wasn't it?

MARSH Citra, yes.

HARTLEY That's a French firm, isn't it?

MARSH Yes.

HARTLEY Which caisson was that? Was that the one on the end of William Street or another?

- MARSH No, that wasn't the William Street one. No, it was one elsewhere, and of course the system was then used again because a lot of the caissons were showing signs of trouble as they were sunk. And so this system was used time and time again to hold things into tolerance.
- 24 But the William Street was a different matter. That was an un-sand-drained area and the caisson began sinking under its own weight, uncontrollably. And so we ceased putting further weight on and it stopped sinking and so we came up with the idea of putting a diaphragm in with a hole in the middle.
- HARTLEY Oh yes.
- MARSH So we did some plasticity calculations to figure out what load was [required] to squeeze that stuff through it, so we could work out the size of the hole we needed and we also conducted tests with modeling clay. And that confirmed the calculations. So the diaphragm was put in. Again, after Citra stopped work and waited to be told what to do. And then when the mud came through we were a little bit [concerned] because, instead of coming up and staying in a neat thing like out of the toothpaste [tube], it started to fragment and fall, but not all that much, and it worked.
- HARTLEY So the diaphragm was actually at the bottom of the caisson, was it?
- MARSH No the diaphragm was ... we couldn't excavate much because as soon as we'd excavate, of course, the caisson would sink.
- HARTLEY Yes, it would go down further.
- MARSH 26 So it was put on the top of the mud at the time so I am not sure how many segments up, it might have been two or three segments.
- HARTLEY It must have been a tricky job to weld it, placing at that level.
- MARSH No, they're concrete.
- HARTLEY Oh concrete.
- MARSH And of course the concrete caissons had rebates, because the caissons had been connected together and prestressing wire strung [through the rebates] to hold them all together. So where these rebates went were ready-made slots to put this diaphragm into. Otherwise we would have had to cut slots somewhere.
- HARTLEY Yes. Another thing you mentioned was that you had the first computer in Western Australia – that was the Bendix, was it?
- MARSH It was a Bendix, yes. It was about the size of a refrigerator - looked like a refrigerator.
- HARTLEY Oh. Quite small for those days.
- MARSH Yes, a valve job, yes. And it had 300 and something, something like 362 bits words of memory.
- HARTLEY Bits.

- MARSH 28 Bits, yes. [laughter] The words were 64 bits long, which is quite long actually. You needed about 60 bits for double accuracy of the number of decimal points for some calculations. So you can fit very large numbers of course into 64 bits.
- HARTLEY So the Bendix one was recommended by the consultants.
- MARSH That was recommended by De Leuw Cather, yes. You didn't have to programme it only in machine language. It had its own language, and it had some very good engineering programmes, roadwork programmes, and that was the reason De Leuw Cather had it, of course, geometric design programmes. And it also had very advanced slip circle analysis programmes.
- HARTLEY Oh yes. That would be useful.
- MARSH They were very useful in the stabilising works of the Narrows Interchange, we used it. And then we also wrote many, many programmes for it.
- HARTLEY So at the end of the Narrows Bridge, or during the final stage, how many people did you have working on that in your department?
- MARSH I had about a hundred engineers and draftsmen working for me.
- HARTLEY Was that the same when you went on to the northwest work as well? Did you have to increase it when you went on to the northwest work?
- MARSH 30 No, no. It was fairly constant. I think it was about 70 odd draftsmen and the rest were engineers and engineering assistants. Yes.
- HARTLEY After the Narrows Bridge there were other major structures.
- MARSH And also a good landscape architect.
- HARTLEY There were other major projects in the metropolitan area too.
- MARSH Yes.
- HARTLEY Which ones were they?
- MARSH Until sometime during the period when I think I was Assistant Chief Engineer, I was also responsible for construction. But around about the time when all the work started on the Narrows Interchange we went in for contract work, to a large extent, and a project office was created and my offsider, Mike Parsons, then shifted over to that in charge of the projects and that then came under the Chief Engineer Construction instead of the Chief Engineer Design, so, at that stage, I lost control of construction, which I felt was quite a bad thing on major construction because a whole lot of rather difficult situations occurred when the construction staff took responsibility to continue certain things, which I only found out when I went down to the site. And there could have been very serious consequences. You know, consultants always retain their control of construction. This control thing being passed over from the design people has occurred in public works all over the world and it's crazy.

End of Side A, Tape 3***Side B, Tape 3***

Tape 3
Side B
minutes

- MARSH 00 Until sometime during the period when I think I was Assistant Chief Engineer, I was also responsible for construction. But around about the time when all the work started on the Narrows Interchange we went in for contract work, to a large extent, and a project office was created and my offsider, Mike Parsons, then shifted over to that in charge of the projects and that then came under the Chief Engineer Construction instead of the Chief Engineer Design, so, at that stage, I lost control of construction, which I felt was quite a bad thing on major construction because a whole lot of rather difficult situations occurred when the construction staff took responsibility to continue certain things, which I only found out when I went down to the site. And there could have been very serious consequences. You know, consultants always retain their control of construction. This control thing being passed over from the design people has occurred in public works all over the world and it's crazy. It shouldn't occur.
- 02 Anyway, it happened, and Mike Parsons was very good in keeping me informed but there were often people beneath him who took responsibility in foundation situations mainly, but also in construction situations. A bad one occurred on the Mount Henry Bridge as well. On one occasion, in order to float in the segments, they dredged in front of the north shore abutment. I became aware that they didn't realise that that was a design problem. And so when I had the stability analysis done on the north shore – the north shore piers were on spread footings, not on piles.
- HARTLEY Oh.
- MARSH It would have gone into the river. And so we overcame that by soil prestressing. We prestressed the soil and until the back filling could occur (we had to excavate a channel to float the barge in).
- 04 There was another dangerous thing occurred but I forget exactly. It was while they were putting up the false work when they were cantilevering it out. Anyway, I just forget what it was, but it involved loads on the structure which were far too high and, again, the construction people had taken the responsibility without realising there was a problem.
- HARTLEY Do you think that was one of the things which increased a tendency for contracts to be let for design and construct?
- MARSH I don't know. I think it was mainly economic.
- HARTLEY Oh yes.
- MARSH It was thought that that might be a more economical way of doing it. Yes. [laughs] They used to hate me coming down to the job, because I kept on finding things out! They reckoned I was spying on them.
- HARTLEY It's a beautiful bridge, the Mount Henry Bridge.

MARSH Well, they've spoilt it now.

HARTLEY Oh yes.

MARSH We had spent a lot of time in developing the aesthetics with Professor Stephenson.

HARTLEY So what was the principle of the changes of grades and levels on the Mount Henry Bridge? The spans.

MARSH 06 Well, I suppose, there were two things about it. During the development of the thing, we wanted to keep it as shallow as we reasonably could – the profile. We needed the spans wide enough and long enough so that the appearance was good and also it is on a bend in the river and we wanted plenty of visibility for river craft because its used by water skiers, so it could be quite dangerous if there wasn't good visibility.

HARTLEY Yes.

MARSH And so the piers were kept down as narrow as possible so that's why we had small piers. Initially, when I did the design I allowed anybody who wanted to to produce a preliminary design and thirteen of the staff had a go.

HARTLEY Oh good.

MARSH And that was quickly reduced to nine. There were some suspension bridge type things, but really inappropriate and so it was reduced to nine. Nine of the designs were then developed and they went out for public scrutiny, particularly in the adjacent local authority areas and also ...

HARTLEY Especially as you lived in Mt Pleasant.

MARSH Yes. So they went out there and also architects were involved and anybody who wanted to put in their ... anyway, I had a go myself and my design was chosen.

HARTLEY Oh. I am sure it was the best one!

MARSH 08 Well, I think the reason it was chosen was because I put the footways underneath the deck, instead of on the deck. And, remarkably, I can only find one bridge internationally that's had that.

HARTLEY Really?

MARSH Yes.

HARTLEY Because it's a marvelous idea, when you've got a high wind bridge, to have the footway under.

MARSH Yes. And of course now we've got three on them in WA, with the footway under the bridge. But I'm sure that was why it was chosen. And it was universally chosen. But my piers they came down and then were enlarged at the bottom, but Jeff Smith – you know Jeff, do you?

HARTLEY Yes.

- MARSH Jeff, who was then leading the design team, he had a look at it. Oh Ken Michael might have been ... anyway, I forget. Anyway, Jeff was on the design team and he reckoned that he could come up with it narrowing down all the way with very heavy reinforcing, and so we conducted some model tests and it worked. So the piers were narrowed down even further and made it safer for the river craft. But of course the whole aspect of the thing is now spoilt with the [railway.] [laughs]
- HARTLEY Yes, it is a pity that they couldn't have thought better of the aesthetics when putting the new two lane bridge on.
- MARSH 10 I suppose in retrospect we should have designed the wider bridge straight off, but that was considered but the cost at the time mitigated against it, although we needed the extra width in such a short time that we should have gone ahead.
- HARTLEY What was the next major bridge after the Mt Henry Bridge?
- MARSH Well after Mt Henry, it was the bridge over the inlet at Mandurah.
- HARTLEY Oh yes, is that the one when you introduced incremental launching?
- MARSH Yes, that was going to be the first incrementally launched bridge – but it wasn't! [laughs] By the time we had commenced construction, Ernie Evans had beaten us to it. And one of our own bridges – I should have banned it!
- HARTLEY That's Ernie Evans of Bruechle, Gilchrist and Evans?
- MARSH Yes. Ernie, I reckon, was the best bridge engineer in Australia by far.
- HARTLEY Really.
- MARSH Yes, a very good engineer.
- HARTLEY That's something, coming from you!
- MARSH Yes? [laughs] He put so much work into the preliminaries that he always came up with a first class solution.
- HARTLEY What do you mean by incremental launching?
- MARSH Incremental launching in simple words is you start off building the bridge on the bank and when you've got more counterweight than bridge, so they won't fall into the river, you push it out and then you put another bit on behind, cast another bit on behind and then push it out again.
- 12 So you really have permanent form work and as soon as a segment is completed, it is pushed out and then – it is just permanent base and sides, I suppose, and then you complete the reforming again, cast the next section and then push that out. And you have a launching nose on the front, a light launching nose so that when it approaches the next pier, the launching nose lands on the pier and supports it as it is pushed out.
- HARTLEY So between that abutment and the first piers there's false work built for it to go on to? Is that right?

- MARSH No, no. There's no false work built. The launching nose, it goes across the complete span.
- HARTLEY Right. So you don't have any false work underneath the bridge segments.
- MARSH No, no. I think that maybe in some places they do build a temporary intermediate pier, but no, the normal thing is you don't. Leonhardt and Andre in Germany, they developed the system. They were responsible for developing a lot of bridge building systems because of the immense amount of work that occurred in Germany following the war.
- HARTLEY They had to rebuild almost all their bridges, didn't they?
- MARSH 14 Yes, yes. Oh, Mount Henry, we considered for incremental launch, but ... [pause] we engaged contractors when we were doing the design to offer construction information that might be important and at the time, when the cost of putting the additional pier supports needed, because of the narrowness of those piers, it was going to be cheaper to put the segments on false work. So that's why we chose the system that was used there, so the first incremental launch then was this one in Mandurah and ...
- HARTLEY That was the first design, anyway.
- MARSH Yes, we engaged Leonhardt and Andre at the time to do the design check and I got quite friendly with Leonhardt and the engineer who came out to do the design check.
- 16 Leonhardt wrote a book on bridge aesthetics and so he did a tour of the world, and when he went around Australia he reckoned that the bridge aesthetics in WA are the best in Australia.
- HARTLEY Oh, that's lovely.
- MARSH Yes.
- HARTLEY That was a marvelous comment.
- MARSH Yes, the Narrows Bridge was extremely important because that set the scene for bridge aesthetics in WA. You didn't stint what you did. Aesthetics were important, so you paid for aesthetics.
- HARTLEY What was the bridge that Ernie Evans launched before your bridge.
- MARSH Oh, it was a bridge over the railway on Tonkin Highway.
- HARTLEY Oh.
- MARSH [laughs] And seeing as though I approved designs, I should have disapproved it, shouldn't I!
- HARTLEY Or not to to be built before such-and-such date! [laughter]
- After the metropolitan work, there was a lot of work on the national highway work, in the Pilbara and the ...
- MARSH Oh yes.

- HARTLEY That must have been a huge amount of work.
- MARSH Yes. The Northwest Coastal Highway was the main one. I suppose the importance of that one, we were building what we called all weather roads.
- HARTLEY It's a dangerous thing to say though, isn't it?
- MARSH 18 Well, we knew they weren't all weather because we were unsure of the rainfall and run off in the Pilbara. We only had the 24 hour recordings, so there was no continuous recording pluviograph. The only one in WA was in Perth and, of course you needed the continuously recording pluviograph records going back, you know, a hundred years, really to know what you are talking about.
- Also, we couldn't really afford to build bridges that were going to take large floods so we decided on building the bridge waterway to take a 20 year flood and then putting in a floodway so that the bridge and floodway would be passable for a 50 year flood. So that was the criterion we used.
- HARTLEY So that was a floodway on the main road before you got to the bridge, was it?
- MARSH Yes, or both sides of the bridge, or one side. There were one or two bridges where you descended into the waterway without the possibility of putting in a floodway.
- 20 One of these was the river just south of the turn-off into Exmouth. No, that's not the one. No, it's north of that.
- HARTLEY We will put that in later.
- MARSH Anyway, I forget the name of the river and there we protected the embankment for larger floods. And also we designed that one for a 50 year flood, we thought. And designed the approaches so that hopefully they would withstand water going over the top. Actually, I don't think water's ever gone over the top of that one. It will one day.
- HARTLEY Yes.
- MARSH Now, what else were we talking about?
- HARTLEY The aesthetics of bridges up there
- MARSH Yes, so the first bridges were ... well, this one I was talking about, there were fairly short spans with inverted T's filled in with the concrete, and then there were a number of bridges including the Yule and the Turner, the bridge near Karratha over the Maitland River and there were a couple further south.
- 22 They were quite large bridges, most of them, and there we used continuous composite construction. Usually when we build, we wanted to put compression in the deck because we weren't confident that putting in shrinkage steel would control the cracking. Did we talk about this last time?
- HARTLEY Only on the Causeway Bridge. Yes.
- MARSH Yes. Now this business of putting compression on the deck was common in Germany. Maybe Leonhardt and Andre developed that system as well. I don't know. Anyway, the way they did it there, they pushed all the steel work out

and then they jacked it up to form a shallow arch. So in a long bridge, you might be up three or four metres in the centre of the bridge, and you had to lower it three or four metres after the concrete had been cast.

HARTLEY Wow, that's a long way.

MARSH 24 A long way, to put compression into the whole deck. And so I came up with the system of pushing out the steel girders over three piers and jacking them up about 75mm at the centre one.

[break in tape]

MARSH And so we cast the concrete from the quarter point to the next quarter point beyond the jacked pier and then we'd lower the deck that 75mm and extend the steel beams to the next pier. And that would put sufficient compression in the deck from that quarter point to the next quarter point. And then we would repeat that process. And so you've got a variable compression which was perhaps minimum in the middle of the span and greatest over the piers where you needed it. That worked very well using small hydraulic jacks. And it was a very simple procedure which could be done with hand jacks, no problem at all. So one of the papers in that list is about that system.

26 Then we went to a different design, and in the different design later on we had concrete diaphragms which also connected the beams of adjacent spans. So the steel beams had a concrete diaphragm over the piers and I think we had hinges as part of the pier and the whole system of concrete pier and cross-head were all part of the hinge system, so we didn't have to have bearings. All sorts of things like that. And that system wasn't really suitable for this jacking business, so the thing was, I don't think the jacking design has ever been repeated, but the alternative turned out to be cheaper than the jacking system, probably because of the simplicity of the steework.

HARTLEY How do the piers and the diaphragm flex, that you were saying, without any expansion joints?

MARSH Just with concrete hinges.

HARTLEY Concrete hinges.

MARSH 28 Yes, the concrete hinge, I think, was developed by Freysinnet in France. So they are designed to hinge ...

HARTLEY So the whole pier hinges or just the ...

MARSH The top of the pier.

HARTLEY Top of the pier, yes.

MARSH Yes, just a hinge. Well, maybe two hinges, one at the bottom of the pier and one at the top. That sort of thing.

HARTLEY There are very extreme conditions in the Kimberley area temperature wise.

MARSH Yes.

HARTLEY What did you have to do differently in the Kimberleys because of the temperature range?

MARSH 29 Well in the Pilbara ... well, of course, it gets hot down here as well. So we would have fixed piers in the middle and expansion joints on both ends. And usually then we would have an approach span which was built on to the embankment of one end and supported on the abutment pier at the other end and the expansion joint was over the abutment pier. So they were generally finger joints, but there are quite a number of large rubber systems too. You can have rubber joints that can be this wide, so that they could be sliding joints as well. The rubber joints make a seal. With the finger joints, we generally have a trough underneath to collect the water and discharge it.

HARTLEY So the rubber is okay even in the very high temperatures?

MARSH Oh yes.

HARTLEY Because that is why O'Connor didn't want to have rubber joints in his pipeline.

MARSH Oh yes. Well, I mean they've got rubber that will stand those conditions. They've got neoprene joints, neoprene mainly, synthetic rubber.

HARTLEY Oh yes.

MARSH The other thing about those bridges was the control of the water and the problems with scour and the building of concrete abutments. With concrete abutments, you are still going to have problems with scour, and you have got to protect with rock work eventually, somewhere. Considering that, the best solution was to just have an abutment maybe consisting of a simple pile bent, which was embedded in the embankment and protect the whole embankment.

32 You had to build a guide banks that went far enough so that the water was discharged away from the abutment area.

End if Side B, Tape 3

Side A, Tape 4

Tape 4
Side A
minutes

MARSH 00 The other thing about those bridges was the control of the water and the problems with scour and the building of concrete abutments. With concrete abutments, you are still going to have problems with scour, and you have got to protect with rock work eventually, somewhere. Considering that, the best solution was to just have an abutment maybe consisting of a simple pile bent, which was embedded in the embankment and protect the whole embankment.

You had to build a guide banks that went far enough so that the water was discharged away from the abutment area.

02 The construction of that rock work is critical. It had to be done very, very carefully and the way it was done is you build up – so you always have a platform – you push the large rocks to the face and then you build what you call a Terzaghi filter behind. Do you know of a Terzaghi filter?

HARTLEY I know the name, I am not quite sure what it is.

MARSH Well, the Terzaghi filter consists of stone work which is in layers of progressively smaller diameter.

HARTLEY Oh yes.

MARSH So that fines can't get through it. So you push the large rocks to the face and then you push in the finer material behind with a bulldozer and you can't just build the embankment layer by layer and then put the rocks on it, because high velocity water will get in behind and take it out. Supervision, that was critical on that work. And we have had some failures, and the failure is due to bad supervision.

We also found that we didn't need to build it layer by layer to make the filter. What we needed was to get a well-graded natural material and put that in behind and that would withstand the high velocity of water on the face.

- 04 So it made its own Terzaghi filter basically, because the fines would just get washed out with the water for a little bit behind and then you'd have big thickness of graded material. You know, of large stuff down to fine rock, so that that worked fine.

HARTLEY Was it difficult to find that natural material?

MARSH No it wasn't difficult to find. No, we found that that was quite easy to find.

HARTLEY Oh.

MARSH Up in the rocky Pilbara, yes.

HARTLEY Some of the bridges and roads in the Pilbara and the Kimberley are very beautiful to look at. What sort of aesthetic judgement did you use? They are beautiful to drive along, beautiful to look at.

MARSH Oh well, I think we nearly always had Stephenson look at our designs and I think that mostly they just developed from the needs of the structure itself.

- 06 What I found was in designing structures was that when you came on to, for example, the design of piers, because they were indeterminant structures, they weren't hinged, they weren't simple to calculate and so the tendency was to choose something which you felt would resist the forces – with batter piles and vertical piles, and so on. Then you simply adopt that because, at that stage, we didn't have the powerful computers needed to develop designs. And I think the thinking was that you just came up with a form and then did the design and maybe modified it slightly, but did not look at it too critically because of the difficulties of the calculations without a computer. But when you started looking at things very critically, on the loads on piles and think, now how can I equalise the loads in those piles, instead of maybe increasing the intervals between piles or something or increasing the size of the piles so that the design that was chosen would be enough you can modify and repeat calculations rapidly with the computer and you can quickly assess what is needed to achieve maximum efficiency. So, for instance, for the abutments on Mount Henry Bridge, the initial design came up with about 40 odd piles. And when you looked at it and looked at it very critically as to how you could

you equalise the loads, we reduced the number of piles in the abutments to 24 – an enormous difference.

HARTLEY Yes, amazing.

MARSH 08 And that applied to any indeterminate structure when you really started looking at it critically. I remember one of the early ones we did was the bridge over the Fitzroy at the downstream crossing on the way to Derby. What's the name of that crossing?

HARTLEY Willare?

MARSH There we perhaps adopted an initial commonly used concept of a pier with a batter pile at each end and a couple of vertical piles between and ran it on the computer. Then change the batter, for instance, and do another run and look at the result.⁵

I put a young engineer on to that and so he just followed his nose on the computer, on the Bendix. And he would come and discuss each one and I would tell him to go back and do this and that.

The final result was quite counter to the initial form. The piers on Willare Bridge finished up with four piles of decreasing batter with the fourth upstream pile vertical. Loads were more equalised than with the other arrangements.⁶

10 Then you've got an extreme load. We would always design these for debris collection. Then the whole thing would deflect and you'd get lateral earth pressure on the piles. And that pressure increases according to the amount of deflection occurring, so wherever the pile might be, however it deflects, you've got this interaction. So the design of these is very complex, because you've got this interaction between the soil and the pile; you've got great indeterminacy, so it takes a lot of computing.

HARTLEY Yes.

MARSH And then you've got to consider scour as well.

HARTLEY Oh yes. The scour in some of those big Kimberley rivers is huge, isn't it?

MARSH Yes, on Mini Bridge, it was. When we did the design for the Fitzroy Crossing Bridge at Willare and Mini Creek to replace the Yeeda crossing which was a little old timber bridge. The flood plain there, as it approached King Sound it has all these flood channels. You had the main river crossing coming in, but you had all these flood channels as well. So we did a model test for the flow in this area to determine the best site. We modeled for 10 miles upstream. We didn't know what the flow was because we had no records.

12 But, my brother who is in the soil conservation section in the Agricultural Department, mentioned a building at Liveringa, which had a flood mark, the 1914 flood mark way up on this building. So we did a hydraulic study and determined that that flow, being the highest flood known, determined the flow

⁵ This paragraph was revised by Mr Marsh on the transcript draft

⁶ This paragraph was added by Mr Marsh on the transcript draft

from this flood, so we used that. We've had one since which was the same size as 1914. So there's probably about a 50 year recurrence interval. And the best place was just right at the top of our model where there's two main channels, at Mini Creek and the main channel. Mini Creek was on the south bank, the main channel was near the north bank and we had a big lake in the middle called Ski Lake which was also bridged in later years

HARTLEY Where was the worst scour?

MARSH The worst scour was on Mini.

HARTLEY Ah, yes. I see.

MARSH 14 When we started, we just put an embankment right across the flood plain. We only had the two bridges, Mini and Willare, and then we put guide banks out from the embankment so that any water discharging had to go around the end of these guide banks and then into Mini. Well, we knew we were going to get a lot of scour. I think we did make an estimate. I forget what we got, but we got three metres of scour there, which I think was probably about what we had estimated.

HARTLEY Yes.

MARSH And of course, some of the diverted discharge went into the main channel as well, but the fall of the land to those bridges was such that most went into Mini Creek.

HARTLEY You tackled the worst rivers first, the Fitzroy.

MARSH Oh well, it was part of the Beef Road Scheme.

HARTLEY Oh yes. Oh Beef Roads.

MARSH Yes, the Kimberley ones are part of the Beef Roads Scheme. There was a crossing at Fitzroy Crossing, it had been built in 1934. We raised that with pre-casted units. Jim Leslie went up there and supervised the construction of that.

16 Maybe Jim only, maybe he came to the Main Roads and wasn't seconded to Maunsells at that stage. Anyway, he went to Maunsells after – however it turned out, I forget.

We had a timber bridge at Liveringa. That was part of the Camballin Scheme, sorry.

HARTLEY Yes, they had some pretty difficult water conditions at Liveringa, didn't they?

MARSH Yes, yes.

HARTLEY I think they said in the Public Works Department book that it rained in the wrong place.

MARSH It rained in the wrong place! [laughter]

HARTLEY I want to ask you about your work for NAASRA

MARSH National Association ... Oh sorry, actually, it started off as COSRA, which was the ...

HARTLEY Commonwealth something, I suppose.

MARSH I might have it there. I might have an old COSRA document.

[break in tape]

Continuation of interview on 29th January 2009

HARTLEY 18 This is tape 4 and I am talking to Gilbert Marsh again at his home in Fremantle.

You prompted me this morning and said that I hadn't asked you anything about the management of the Main Roads.

MARSH Yes.

HARTLEY I wasn't quite sure how much I was supposed to ask you. Perhaps you could say what your bridge construction management, what areas did it encompass?

MARSH Well, basically, it was a design organisation. We also had a small construction organisation that did work in the Metropolitan Division. But these two little organisations, if there was any specialist work out in the other divisions, then they would go out and do the work under our direct supervision, and I suppose there were about 50 men in the construction organisation and maybe about 12 in the maintenance organisation.

HARTLEY That's the engineering staff.

MARSH No, no. That was the total, workmen as well.

HARTLEY Was it?

MARSH 20 Yes. Oh yes, and we had a drilling organisation as well which did the drilling for foundation investigations. And then we had a waterways team who did the hydrology and the hydraulics for investigations for bridges and then of course we had basically an urban design team and a country bridges design team.

We also got involved in major earthworks around the place as well, that required design, like the Narrows Interchange area and stuff like that. For instance, a problem on the Kwinana Freeway near Canning Bridge, there was a slip circle, there were instability problems. So that was the basic organisation. Oh I liked everybody reporting to me but I was given offsidars which was the way the Main Roads operated, although I didn't really want them. So I kept an open door policy where anybody could come and talk to me but I tried to be careful about advising my offsidars what had been discussed.

HARTLEY And this was all done verbally or using letters and memos and all that sort of ...

- MARSH 22 No no. Oh well, memos are important, of course, yes. So that was how the section operated.
- HARTLEY So there was a hierarchy organisation rather than a flat management like they talk about these days.
- MARSH Yes, yes. I liked Taylor's management scheme which was a flat one. Yes.
- HARTLEY Your offsidars were supposed to take over the management side for you.
- MARSH Yes. I suppose, basically, they were supposed to ... well, they did too. I mean, I liked to let people do what they wanted and that was my philosophy and so John Wheeler – his designs were a bit flamboyant so he designed all these footbridges like arches and suspension footbridges that you see along the freeways.
- HARTLEY Oh yes. That one at Como.
- MARSH 24 Yes. Ken Michael, he had a good aesthetics sense and the Judd Street Footbridge just over the Narrows Bridge towards Mount Henry, that bridge, if you look at it, the sides start off wide at the piers – now this is a continuous what do you call a variable depth structure -- and then towards the centre where the structure shallowed, these sides are sloped inward at the bottom. So it was a bit of an exercise in designing economical formwork because it was cast in place. But compared with bridges with just vertical sides all the way, even if they are arched, it improves the aesthetics tremendously. Leonhardt from Germany, he was very impressed with that -- when I was driving him down the Freeway, he said, 'Stop, stop!' He said. 'That's the most floating footbridge I have ever seen.'
- HARTLEY That was really something, wasn't it!
- MARSH Yes.
- HARTLEY So the Judd Street bridge is a footbridge.
- MARSH Wee, there is the road bridge and the nearby footbridge. Ken was responsible for a few other structures around the place too. He came under Peter Samuel then but then Ken moved out into the divisions. He was looking to [laughs] not to be Governor, but certainly, I think, in the long run to Commissioner.
- HARTLEY And Peter Samuels, he was a man who came from Freeman Fox, was he?
- MARSH Yes, he came from Freeman Fox.
- HARTLEY Did he stay with the Main Roads?
- MARSH 26 No, no. He left, I think, because he would have liked to have been in my position and there was no prospect of that but he stayed on after the Narrows Interchange. He was responsible for the design of the bridges on the Narrows Interchange and a number of other ones, but he also did some bridges out in the country. But his prospects were not what he wanted so he then went out on his own. He was a very good engineer.
- HARTLEY Did Ernie Evans ever work for the Main Roads?

- MARSH No. Ernie never worked for the Main Roads, no. I think I mentioned before, Ernie was an excellent engineer and I reckoned he was the best bridge designer in Australia.
- HARTLEY Geof Fernie says you are.
- MARSH Oh, Geof doesn't know ... Ernie was much more thorough than I ever was.
- HARTLEY Right. You were saying some interesting things about the difficulty of not supervising your designs in the Main Roads.
- MARSH 28 Oh yes. I just felt very strongly that the designer should be basically in charge of the supervision because so much can go wrong, because site staff don't always recognize when the construction involves design. I mean, they might have temporary works that load up the structure too much when they interfere with the foundations in some way. And also, in spread footing, for instance, they don't recognize that the site conditions aren't according to the original investigation. They are the main problems, so I must say that I used to frequently visit jobs watching out for things that might be wrong. But I could never persuade the department that this should be the way that things went.
- HARTLEY You put a great strain on the designer to be responsible for construction as well though, isn't it?
- MARSH Yes, I suppose so. I think it is an additional responsibility but if things go wrong, the designer tends to cop it anyway.
- HARTLEY [laughs] Yes!
- MARSH And some very serious things did occur that were picked up in time.
- HARTLEY You mentioned last time your work for NAASRA but we ran out of tape at the last minute.
- MARSH I see, yes.
- HARTLEY 30 That's the association that takes in all the state road authorities, is it?
- MARSH Yes.
- HARTLEY What was the one before that?
- MARSH It was COSRA – whatever the "C" stands for.
- HARTLEY Commonwealth, I suppose.
- MARSH COSRA. I think it was Conference of State Road Authorities.
- HARTLEY That evolved into NAASRA.
- MARSH Yes, yes and later into AustRoads. Our first bridge design specification that was produced when Godfrey was there, that was under COSRA. But then, I think, in the 50s it was changed to NAASRA.

HARTLEY 31 Where did the initiative come from to form a nationwide organization with all the states?

MARSH I don't know. I think the states had always [cooperated], even when the Main Roads was formed, because of course a lot of the people in the Main Roads came from other states.

HARTLEY Oh yes.

MARSH And there was movement around the states, so I think from very early on there was cooperation between the states and so I guess it just naturally evolved into a peak body, a cooperative organisation – well not exactly a peak body, but a cooperative body.

HARTLEY 32 Sometimes, some organizations in the older states, New South Wales for instance, naturally think they are the boss guy. Did that sort of thing happen in that?

MARSH Yes, well, that did.

End of Side A, Tape 4

Side B, Tape 4

Tape 4
Side B
minutes

MARSH 00 Yes, well, that did. When I first went to meetings, New South Wales was inclined to rule the roost and say I am not going to agree to anything but this. In other words, they assumed power of veto but that quickly disappeared when they realised that everybody had legitimate views, and so we quickly devolved to very cooperative organisations throughout the whole of NAASRA. And of course we traveled a lot to go to committee meetings so we were very close to the people in the equivalent positions in the other organisations in the states.

HARTLEY Did they have any permanent offices, NAASRA? Did they have staff?

MARSH Yes, we had a permanent NAASRA staff, yes. And they would organise the meetings and so we would always have a NAASRA secretary to take the minutes and that sort of thing. Also the Commonwealth was represented on nearly all these committees.

HARTLEY You mentioned the need for a traffic and load survey.

MARSH 02 Yes, Russell Kaesehagen was the Chairman of that committee. It was Road Needs Committee.

HARTLEY Road Needs, yes.

MARSH And they organised to collect certain information within each state – each state had its own little organisation to pick up all the data needed to determine the road needs in each state. And they designed a vehicle to collect a lot of information on road geometry, road roughness, road steepness, road curvature, lateral curvature. So they had inertial measurement things to

determine all these things. And then of course there were traffic densities and I don't know what else but there were a lot of areas ... and then they wrote this programme. Of course the states had been involved in producing this programme, so they all accepted the results.

- 04 But then the Bureau of Transport Economics simply picked up this program to determine the breakup of funds, Commonwealth funds to the states so there was never any quarrel about the break up of funds.

HARTLEY That must be unique in Commonwealth/State relations.

MARSH Yes, it was great. My son-in-law, he's something in the Health Department and you can see the problems that they have.

HARTLEY Yes.

MARSH And I've mentioned to him a couple of times that they really ought to produce a programme to determine state needs, a cooperative program, but it has fallen on deaf ears so far, I think.

HARTLEY Well, they might be forced by circumstances to that.

MARSH Yes.

HARTLEY You mentioned road roughness as a major factor.

MARSH Yes.

HARTLEY I suppose for unmetalled road was very important too.

MARSH For which?

HARTLEY Unpaved roads.

MARSH Oh yes but it was for paved roads also. I mean if you are going on a long country trip you become aware when some of the stretches are uncomfortable and so they had thresholds above which the roughness was unacceptable and of course, with the funding recent years, the amount that could be spent on reconstruction and maintenance has decreased.

HARTLEY Has it?

- MARSH 06 Yes. So that if you go out now, you'll find a lot of roads very uncomfortable there and they are obviously below standard. And I think that would apply to the whole of Australia.

HARTLEY You mentioned one thing – they didn't have a way of measuring loads, axle loads.

MARSH Yes, that came out of the road needs as well. So the states then started looking at how they could get data on the loads and first of all they looked at load platforms but ...

HARTLEY That would mean that the trucks would have to drive off the road.

MARSH No. They'd have platforms set in the pavement.

HARTLEY Oh yes.

MARSH Yes, and I think the Road Research Organisation in America, they had devised some of these platforms but their accuracy wasn't very good. They were about plus or minus ten per cent. Then in America, they devised a system called Bridgeway where they used bridges to determine it. So they had strain gauges on bridges and they'd have detectors at the approaches of the bridge to determine axle spacings and from these measurements they could deduce the a lot of the axle loads. That was reasonably accurate but the system was fairly unwieldy in many ways.

08 Anyway, they patented that, we tried the system on bridges where we found some loopholes in the Bridgeway system and it involved quite a lot of work on some bridges to get the measurements – we not only measured strains, we measured deflections as well – and the whole thing on bridges wasn't all that good.

And then Tom Pedersen who looked after heavy loads in the Main Roads Department – he was Executive Engineer and had that as his function – he said why don't you strain gauge some culverts, they are small bridges, aren't they? And of course culverts are covered with a lot of over-burden and so I thought they are not likely to be much good but I thought, oh well, I will give it a go. So we tried it out. Joe Wyche and Bob Peters looked at it and they found that they could determine the loads within five per cent accuracy with these. Very good.

10 And so they developed this system called Culway, and the Road Research Board picked that up and produced publications on it, and that was then put into operation all around Australia. The Road Research Organisation in America, they were very interested in it too and they got onto the Road Research Board to follow that up. I don't know what happened about that. But it was so good, I imagine they would have done something about it.

HARTLEY Whereabouts in the culvert were the strain gauges put?

MARSH They were generally put at the top, but I think that cracking might have created some problems there. Although the response to loading might have been non-linear but one of the key things about this system was that you put over vehicles of various weights to check it out so even if you had a non-linear response, each one had its own individual response so that worked fine. And the system, of course, had detectors which detected not only the axle loads but also the longitudinal and transverse position of the vehicle coming over, because that was also important.

HARTLEY 12 Yes. How many culverts in a main road would you put in the system? How often were they put in to determine loading?

MARSH I don't know.

HARTLEY Every hundred miles?

MARSH There would be maybe one or two on each major road, I would think, something like that. No, I don't know. Because you of course had to have a recorder on each one and I am not sure if they ... they probably worked with

samples as well. They would operate one for a while and so we'd basically get samples I would think. Otherwise, it would get a bit unwieldy I would think.

HARTLEY Yes. They could be removed quite easily and moved to another site.

MARSH Oh yes. I mean you would just have the strain gauges and whatever other measurements you had – maybe, deflection measurements. You'd have those up to a control box and you could just plug a recorder into the control box.

HARTLEY So someone would just have to go around and inspect them every now and again.

MARSH 14 Yes. After I left, I also tried out, because the culverts had been so good, I thought a lot of places didn't have culverts and so I investigated putting strain gauges into holes in the ground. So I did that at the university after I retired. So a report was produced. It wasn't bad but it wasn't nearly as good as Culway and I don't know if any were installed later. We put a couple of installations in, one on Tonkin Highway and another one somewhere else, but the accuracy wasn't as good as Culway – it was probably about plus or minus seven per cent, I think, something like that. And so the culverts were a much better bet. In fact, so much so that in some places, we actually put culverts in just to get the measurements.

HARTLEY Oh that's a good idea. You mentioned earlier that there was a change in the design codes from Elastic State Design to Limit State Design.

MARSH Yes.

HARTLEY How long a period did that take you to evolve?

MARSH 16 The Limit State Design didn't come in until towards retirement. I mean, we went on to Limit State Design before I retired. I think the Limit State Design code didn't come out until after I retired, and so I was a consultant seeing that through to publication.

HARTLEY That was for all concrete design, steel design and ...

MARSH Yes.

HARTLEY You mentioned that some of the European countries had used that before.

MARSH Yes, the first one was Czechoslovakia. They adopted Limit State Design long before anybody else. And I suppose that when we developed it, I think that probably some of the other countries had picked it up by that time, but we were all around about the same time.

HARTLEY What's the basic difference between Elastic Design and Limit State.

MARSH 18 Well, the basic difference is that Limit State Design, of course, you have a known factor of safety against failure, whereas Elastic Design, you have a known factor of safety against exceeding the plastic limit but that doesn't tell you what the factor of safety against failure is and the factor of safety against failure is more important than the factor of safety against plastic behaviour.

HARTLEY Yes. When did you retire from the Main Roads?

MARSH I retired in December 1985.

HARTLEY That was when you were sixty, was it?

MARSH Yes, when I was sixty, yes. I think by that time ... there hadn't been much change in my organisation and everybody could do what I wanted them to do and the way I wanted them to do it and there was no point in me poking my nose in. And so that sort of went on for a while and so I looked around for jobs to do and so I got jobs like coming up with a policy for fencing in the Main Roads Department and stuff like that, and so I got out.

HARTLEY You didn't have any offers from universities, to be a professor at a university.

MARSH No. At one stage, I did lecture on bridge design, but I think I was such an awful lecturer [laughs] nobody would want me for that.

HARTLEY I don't think that seems to deter a lot of other lecturers, anyway, in engineering. What sort of consultancies did you do after you left the Main Roads.

MARSH 20 Well, after I left, I suppose my main areas of consultancy were in foundations and waterways. They were areas where the computer programs perhaps weren't as sophisticated as they were in structures and so – the waterways especially were a bit of a black hole. But I think now, things have probably changed a lot. You see, in the waterways, in the department, when we did the bridges up north, although we aimed to have them passable for the 50 year flood, the bridges were really designed just for a 20 year flood, so you had tremendous scour problems and protection problems. These bridges were always put above a reasonable flood so that the water wouldn't go over the approaches. That wasn't always possible, but then perhaps we would design the height for a 200 year flood or something like that, so the water wouldn't go over. Although of course we had the flood crossings as well. And, I think I mentioned before about the construction of the protection works – how that was constructed - the supervision had to be very close, and that wasn't always achieved.

HARTLEY You can't put that in a manual, can you, exactly what you have to do in supervision?

MARSH 22 No, but mostly the supervision for these bridges was actually provided from the bridge section and went under Mike Parsons. Mike was responsible for the construction of contract bridges, but the supervision often came from our own organisation, but of course reported to Mike. So they had some idea of what was needed, but it wasn't always achieved. And also the magnitude of floods, we had very little information out in the back blocks for that and I think I've spoken about that elsewhere. So that generally we found that our estimates were a bit on the low side, and so we have had a few failures. But, we always thought that this was going to be possible because we were working in the dark a little bit and so we have had some failures which have been quite costly, BUT, we couldn't afford to put in larger bridges, so that was that.

HARTLEY Like we used to say, it failed according to design.

MARSH Yes [laughter] According to design! Haven't heard that one before. Yes.

HARTLEY 24 You mentioned also that you were doing something on one of the offshore platforms about a foundation failure.

MARSH Oh yes. On the Goodwyn A platform, the contractor had driven all the primary piles without checking what was going on and the ends had closed in and, of course, secondary piles had to be driven through these. So they drove all the primary piles, and then when they tried to drive the secondary piles, they couldn't get them through. They were all closed up. So they had to open these out. So they engaged consultants to solve this problem and the consultants went to the University to do some model testing and the University got me to look after the model testing. The consultant's idea was to put a granular material in the piles, put a seal on the top and then a seal further up the pile and pump water in between, pressurise it and blow the bottom out.

26 They had done some calculations to determine what sort of pressure they would need and they had determined that if they could get up to seven megapascals, I think it was, inside the pile, then they would blow it out. The granular material, of course, wouldn't just blow out the bottom. You can't push a granular material out of a tube because when you put pressure on it, then the granular material expands sideways and so it would jam in the tube but, eventually, with enough pressure you can push that plug out. So that was the theory.

HARTLEY What sort of depth was it?

MARSH The primary piles were thirty metres long.

HARTLEY Thirty metres.

MARSH Yes, and they were up to 2.4 metres in diameter, with a wall thickness of ... oh, very thick.

HARTLEY Right.

MARSH 28 I forget the width. They had to take quite a load. The wall thickness was 27 millimetres or something like that, if I remember. Anyway, so they had to drop this granular material through water so they chose a heavy material, ilmenite, but it occurred to me that the place was lousy with iron ore and so I suggested that they use iron ore fines. This had the advantage not only of being cheap but when dropped through the water in the pile it segregated with the very fine material finishing at the top to form a seal. So in the model testing we used iron ore fines. We found that with three charges – you'd put a charge in and blow it up to seven megapascals. And so in the model testing we had a hundred millimetre diameter piles and I had to make a foundation material out of a limestone material and cement to model the foundation material. It was a soft limestone. And in the model testing, it took three charges to blow the end out to the desired amount. We also tried some mechanical devices. There was a device that – you know, these orange peel grabs?

HARTLEY Yes.

- MARSH 30 So they devised a device, an orange peel device to expand sideways and also driving a cone through it to expand it. I think they were the two mechanical means that were tried.
- HARTLEY So these were open ended piles?
- MARSH Yes, they were driven open ended.
- HARTLEY And they were forced inwards, the ends of them.
- MARSH The other thing was that they should have had a cutting edge. And they had no cutting edge.
- HARTLEY Oh, that's strange.
- MARSH But they didn't want to destroy the outside skin friction but they could have put in a cutting edge on the inside strong enough to do that, but if it had anything to do that with foundations, you wouldn't have driven them like that because that's what always happens. And so that was a design mistake. The designer hadn't picked it up. So that method of just simply dropping iron ore fines through – the other thing about the iron ore fines was that they made a natural seal on the top, so you didn't have to put another seal on top of the granular material.
- HARTLEY So what sort of thickness was it? What length?
- MARSH It was about one diameter. I think if you had too much you wouldn't be able to push it out.
- HARTLEY Yes.
- MARSH But it worked very well and actually in the field it worked with one charge. It worked better in the field than in the model.
- HARTLEY They must have held their breath though, mustn't they?

End of Side B, Tape 4

Side A, Tape 5

Tape 5
Side A
minutes

- MARSH 00 Yes. So it was a very interesting little project.
- HARTLEY Yes. It must have cost a lot of money to actually do it though.
- MARSH Yes. And the key piles then went through another hundred metres or something, yes. They were two hundred metre long piles.
- HARTLEY Did you do any other work for contractors or foundation designs?
- MARSH There was waterway and foundation design. I got involved with the Narrows Bridge widening when they were doing that, and advice on the foundation

conditions when the tunnel through the Narrows Interchange area was being designed.

HARTLEY It was very slushy at William Street. It wasn't consolidated at the William Street end, was it?

MARSH 02 That's right. It was just general advice, I suppose, on what they might encounter on their way through the whole area.

[break in tape - pause]

MARSH 03 When we put in spread footings, we always put in measurement points so we could keep an eye on the settlements because settlements in sand, the Terzaghi formula for it – which was generally used – was not very good. Some more recent methods which depended on cone pressure measurements were available. So we kept a very close eye on these settlements in all sorts of sands until we finally determined what the best approach was.

04 And they weren't bad, actually because, for instance, on the north abutment of Mount Henry Bridge, we predicted that the settlement would be 5/16th of an inch or 8 mm and that's what we got.

HARTLEY Oh, that's very good.

MARSH Yes.

HARTLEY Very reassuring.

MARSH Yes, and generally our predictions were pretty good. I think I mentioned when we did the Hamilton Interchange, we did a test loading, foundation test loading to check out our predictions before we built the thing. But then we gained more and more confidence so we didn't need to do test loading anywhere.

HARTLEY There is a difficult area there though, because there used to be old lakes along that Wellington Street, Hamilton area. There used to be a series of lakes along there, didn't there at Wellington Street.

MARSH Oh yes, that's right.

HARTLEY So that must have complicated matters.

MARSH Oh well, the sand was very well behaved!

HARTLEY Oh, was it?

MARSH We would have been able to predict without any problem because the sand under those lakes tended to be quite dense.

HARTLEY 06 Wasn't there at one time talk about not having the Mitchell Freeway an open cut, but going in a tunnel underneath Kings Park? Do you remember that? Putting the Narrows Interchange in a tunnel, or the approaches, in a tunnel under Kings Park instead of having an open cut.

MARSH Oh yes.

- HARTLEY Do you remember that? I think it was Boas ... going back to the planning days.
- MARSH You mean when we were first looking at the Mitchell Freeway. Yes, that's right. Yes. I don't remember much about that. No. That was pretty early on. Filling the river was there. That was going to be by far the cheapest option.
- HARTLEY Yes. It's the sort of thing that appears in the newspapers, people add their bright ideas.
- MARSH Maybe the consultants looked at that, Maunsells. I don't think we ever looked at it. I think Maunsells looked at it for us.
- HARTLEY Editing the NAASRA codes must have taken up a lot of your time. Was that after you retired or before?
- MARSH 08 Well, before, of course. Well, no. I mean I had assistance. John Wheeler was the steel guy. Ken Michael was the concrete man. So we had some pretty good people looking at it and so it didn't occupy much of my supervision time. Foundations were a bit more difficult, perhaps, because I probably would have been looking at that pretty closely, yes. We had a very good waterway team with David Flavell in charge of that and so we used to do a lot of rainfall and run-off studies to provide information.
- HARTLEY Wasn't there a lot of work involved in the rainfall and run-off in the Pilbara and the Kimberleys by the Main Roads. Was there a lot of hydrology work by others in the Kimberleys and Pilbara?
- MARSH Yes. John Lewis in the Kimberley, yes, he did all the hydrology investigations for the Ord Dam and so on, so we drew heavily on his material, but in the Kimberleys we finished up under designed.
- HARTLEY Oh?
- MARSH 10 And in the Pilbara, we had nothing. There was no long term gaugings of any length, no pluviometer readings and so we had to make do with what we could and I think I have mentioned Karratha before – the information at Karratha and using the daily records which went back seventy years plus some occasional comments about the height of the flood, like the Maitland River ran a banker or two feet over the bank and things like that and we were able to do calculations of rainfall runoff then using the daily rainfall figures to try to correlate the two and that way we came up with information which we used – the only information we had so we used that on lots of bridges on the Northwest Coastal Highway.
- HARTLEY The flood levels are a bit better, more reliable than the rainfall records I should think.
- MARSH Oh well, the rainfall levels of course, you don't know ...
- HARTLEY How do they do them? How do they make ...
- MARSH Well the records might be reliable enough but, I mean, they had records for 24 hours, so you don't know if a rainfall occurred over one hour or 24 hours and so the Institution of Engineers on their first Australian Rainfall and Runoff

publication, which was produced in 1957, they did an analysis of the Perth records.

- 12 They compared the Perth daily records with the pluviometer records, because that was the only pluviometer in the state and so then they determined that they needed to look at falls over three days to get a correlation, and so then they used falls over three days to determine the fifty year frequency in the rest of the state. And came up with some silly results.

HARTLEY Not surprising.

MARSH Yes. I don't know why it was so low, they predicted that the fifty year rainfall in the Pilbara was three inches in 24 hours and I think they came up with the same in the Kimberley. And, of course, you only had to look at the daily records and you knew that that was nonsense.

HARTLEY Yes.

MARSH But the American consultants on the early rail bridges just used that willy-nilly, and wouldn't be told it was wrong.

HARTLEY They gave the subsequent engineers more work to do.

MARSH Yes. Well, they lost a lot of culverts.

HARTLEY And trains too.

MARSH 14 Yes. Oh yes, the waterways business. I did work for various railways up north as well - railway bridge waterways as well as road bridge waterways.

HARTLEY I don't think there have been any new bridge washouts on the railways, have there yet?

MARSH [laughs] No, well, I think that they tended to be fairly conservative on the design of their waterways, yes. It wasn't like us. We were designing basically for a waterway for a 20 year flood.

HARTLEY When you retired, you took up some other interests like botany. How did you get interested in that?

MARSH Oh well, I didn't know what I was going to do, basically. Well I carried on doing consulting and that lasted for fifteen years. But after my wife died I went on a couple of eco-trips including a Landscape trip and on the Landscape trip I met my botanist friend - well, I had known her before actually.

- 16 She had taught with my wife. I got interested in botany and so I became her assistant botanist.

HARTLEY That's a never-ending job, isn't it, being a botanist.

MARSH Yes, it's been a fairly absorbing hobby, yes. And so, we go out as much as three months a year. It might be even more in a couple of years. And I work three days a week at the Herbarium on the various activities including plant identification, which is interesting.

HARTLEY You were saying that they were waiting for some rain in the Shark Bay area.

- MARSH Yes, it didn't occur.
- HARTLEY Didn't it? Oh. It must have been close.
- MARSH The station is not at Shark Bay, it's at Exmouth Gulf.
- HARTLEY Oh.
- MARSH Well, they might have. I am not sure. Geralia. Yes. We have been waiting. The DEC, the Department of Environment and Conservation, they want some more collecting done on Geralia, but Exmouth only got eight milimetres.
- HARTLEY Oh.
- MARSH 18 But south along the highway, Minilya got 57 milimetres. Geralia could have got about that much but looking up the records, there's no record yet for Geralia at that time. Maybe they haven't sent the records in. So I don't know, they could have got 50 or 60 milimetres, so I am still waiting to see.
- HARTLEY At least you are not the pastoralist who has to wait for the rains.
- MARSH Oh no. I mean, there have been some very good rains over a big area. The Holland Track's another area where we want to go and collect. We will be wanting to collect in spring so we are hoping for some more rain, but they certainly had quite a lot of summer rain, but we not really interested in that. So I will be more interested in the spring there on Holland Track. I would have thought it would have been well collected but we went on that last year and we found that every second specimen we looked at wasn't on their species list, so we will go out there sometime.
- HARTLEY Oh, that's very exciting.
- MARSH Yes. So how are we going?
- HARTLEY Oh I think we have just come out at the end of this tape then, so I will say thank you very much, Gilbert. It has been a pleasure to talk to you and I ...
- MARSH And I didn't get you a biscuit.
- HARTLEY 20 I can have one now though.

End of Tape 5

End of Interview